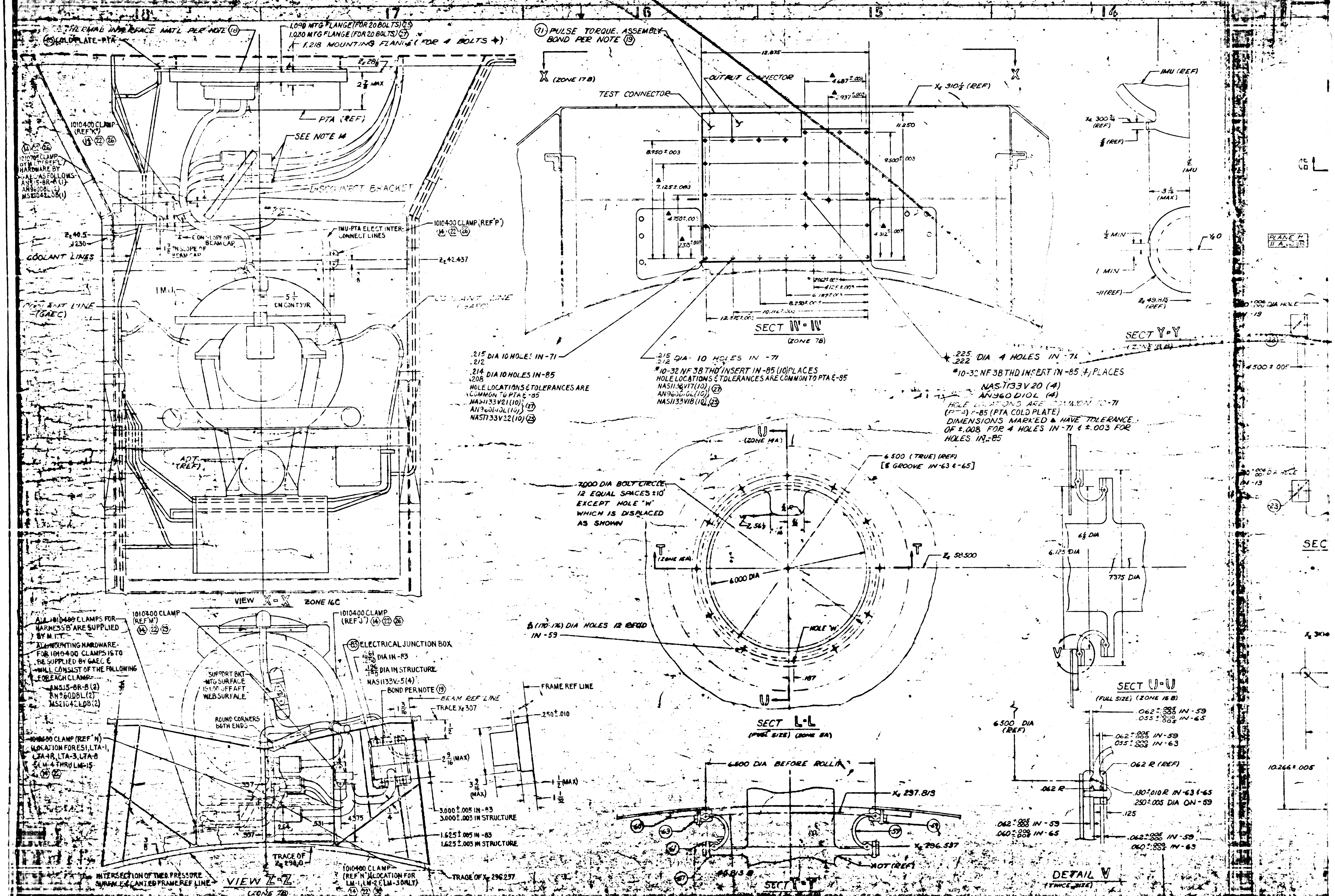
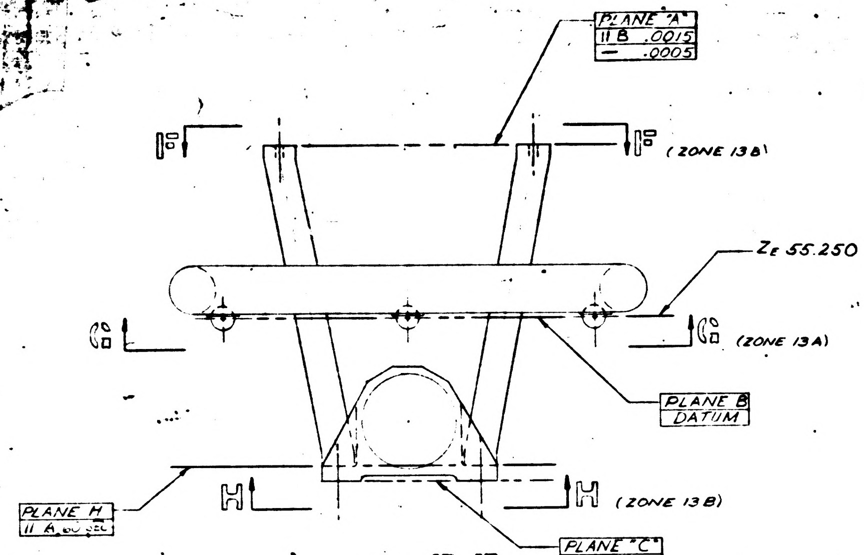
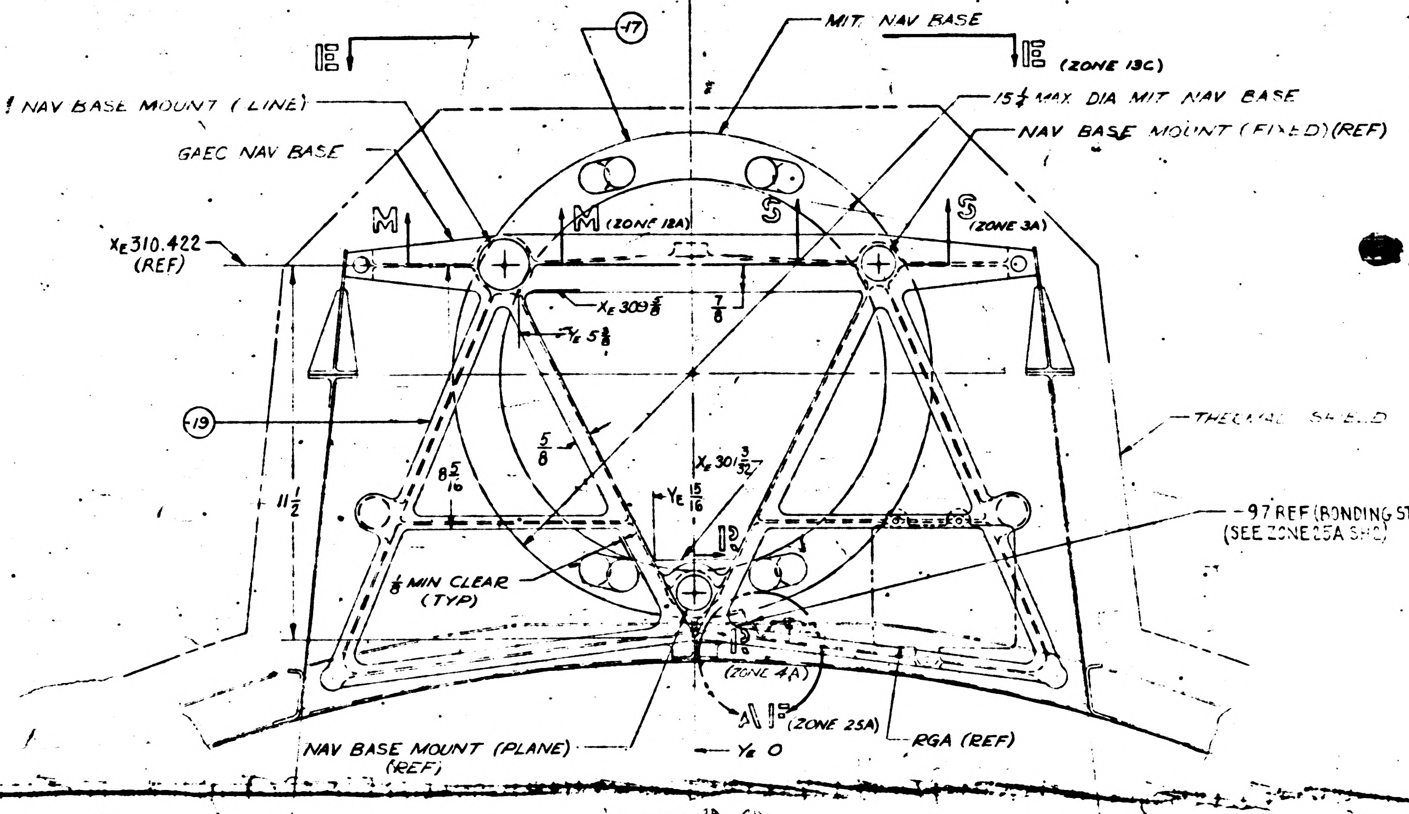


18
17
16
15
14
THERMAL INTERFACE MATL PER NOTE ⑱
COLD PLATE-PTA
1.090 MTG FLANGE (FOR 20 BOLTS) ㉕
1.030 MTG FLANGE (FOR 20 BOLTS) ㉗
1.218 MOUNTING FLANGE (FOR 4 BOLTS ✦)
Z 28
2 7/8 MAX
PTA (REF)
1010400 CLAMP (REF "K") ⑭ ㉒ ㉖
SEE NOTE 14
1010705 CLAMP (REF) HARDWARE BY GAEC AS FOLLOWS AN515-8R-8 (1) AN960D8L (1) MS21042L08 (1)
DISCONNECT BRACKET
Z 40.5
1.230
CONT SLOPE OF BEAM CAP
1 7/8 IN SLOPE OF BEAM CAP
IMU-PTA ELECT INTERCONNECT LINES
1010400 CLAMP (REF "P") ⑭ ㉒ ㉖
Z 42.437
COOLANT LINES
IMU
5 1/2 ON CONTOUR
COOLANT LINE (GAEC)
ADT (REF)
VIEW X-X ZONE 16C
71 PULSE TORQUE ASSEMBLY BOND PER NOTE ⑲
X (ZONE 17 B)
X
OUTPUT CONNECTOR
TEST CONNECTOR
X 310 1/2 (REF)
12.875
4.687 ±.003
2.937 ±.003
11.250
8.950 ±.003
9.500 ±.003
7.125 ±.003
4.750 ±.003
2.375 ±.003
4.312 ±.003
2.062 ±.003
4.125 ±.003
6.187 ±.003
8.250 ±.003
10.312 ±.003
12.375 ±.003
SECT W-W (ZONE 7B)
.215/.212 DIA 10 HOLES IN -71
.214/.208 DIA 10 HOLES IN -85
HOLE LOCATIONS & TOLERANCES ARE COMMON TO PTA ℄ -85
NAS1133V21 (10) ㉗
AN960D10L (10) ㉗
NAS1133V22 (10) ㉕
.215/.212 DIA 10 HOLES IN -71
#10-32 NF 3B THD INSERT IN -85 (10) PLACES
HOLE LOCATIONS & TOLERANCES ARE COMMON TO PTA ℄ -85
NAS1133V17 (10) ㉗
AN960D10L (10) ㉗
NAS1133V18 (10) ㉕
✦ .225/.222 DIA 4 HOLES IN -71
#10-32 NF 3B THD INSERT IN -85 (4) PLACES
NAS1133V20 (4)
AN960D10L (4)
HOLE LOCATIONS ARE COMMON TO -71 (PTA) & -85 (PTA COLD PLATE)
DIMENSIONS MARKED ▲ HAVE TOLERANCE OF ±.008 FOR 4 HOLES IN -71 & ±.003 FOR HOLES IN -85
IMU (REF)
X 300 3/4 (REF)
5/8 (REF)
IMU
3 1/2 (MAX)
1/2 MIN
1/6 0
1 MIN
.11 (REF)
Z 49.814 (REF)
SECT Y-Y (ZONE 8B)
PLANE H II A
DIA HOLE
-19
4.500 ±.005
-13
㉓
SEC
U (ZONE 14A)
6.500 (TRUE) (REF) [℄ GROOVE IN -63 & -65]
7.000 DIA BOLT CIRCLE 12 EQUAL SPACES ±10' EXCEPT HOLE "W" WHICH IS DISPLACED AS SHOWN
Z 56
T (ZONE 15A)
T
Z 58.500
6.000 DIA
(.170-.176) DIA HOLES 12 REQD IN -59
HOLE "W"
.187
U
SECT L-L (FULL SIZE) (ZONE 5A)
6 1/2 DIA
6.125 DIA
7.375 DIA
V
SECT U-U (FULL SIZE) (ZONE 15 B)
X 304
10.266 ±.005
.062 +.005/-.000 IN -59
.055 +.005/-.000 IN -65
.062 ±.005 IN -59
.055 ±.005 IN -63
.062 R (REF)
.062 R
.130 ±.010 R IN -63 & -65
.250 ±.005 DIA ON -59
.125
.062 +.005/-.000 IN -59
.060 +.000/-.003 IN -65
.062 +.005/-.000 IN -59
.060 +.000/-.003 IN -63
6.500 DIA (REF)
DETAIL V (TWICE SIZE)
6.500 DIA BEFORE ROLLING
X 297.813
X 296.537
ADT (REF)
SECT T-T
ALL 1010400 CLAMPS FOR HARNESS "B" ARE SUPPLIED BY M.I.T.
ALL MOUNTING HARDWARE FOR 1010400 CLAMPS IS TO BE SUPPLIED BY GAEC & WILL CONSIST OF THE FOLLOWING FOR EACH CLAMP:
AN515-8R-8 (2)
AN960D8L (2)
MS21042L08 (2)
1010400 CLAMP (REF "M") ⑭ ㉒ ㉕
1010400 CLAMP (REF "J") ⑭ ㉒ ㉖
83 ELECTRICAL JUNCTION BOX
.261/.250 DIA IN -83
.136/.130 DIA IN STRUCTURE
NAS1133V-5 (4)
BOND PER NOTE ⑲
SUPPORT BKT MTG SURFACE IS 1.00 OFF AFT WEB SURFACE
FRAME REF LINE
BEAM REF LINE
TRACE X 307
.250 ±.010
1 3/16
1/2
ROUND CORNERS BOTH ENDS
2 9/16 (MAX)
3 9/16 (MAX)
1/2 (MAX)
1 1/32
1010400 CLAMP (REF "N") LOCATION FOR ES1, LTA-1, LTA-4R, LTA-3, LTA-8, LM-4 THRU LM-15 ⑭ ㉒
.337
2.64
.531
4.375
3/8
3.000 ±.005 IN -83
3.000 ±.003 IN STRUCTURE
1.625 ±.005 IN -83
1.625 ±.003 IN STRUCTURE
TRACE OF Z 298.0
1010400 CLAMP (REF "N") LOCATION FOR LM-1, LM-2 (LM-3 ONLY) ⑭ ㉒ ㉞
TRACE OF X 296.297
INTERSECTION OF THEO. PRESSURE SURFACE & CANTED FRAME REF LINE
VIEW Z-Z (ZONE 7B)

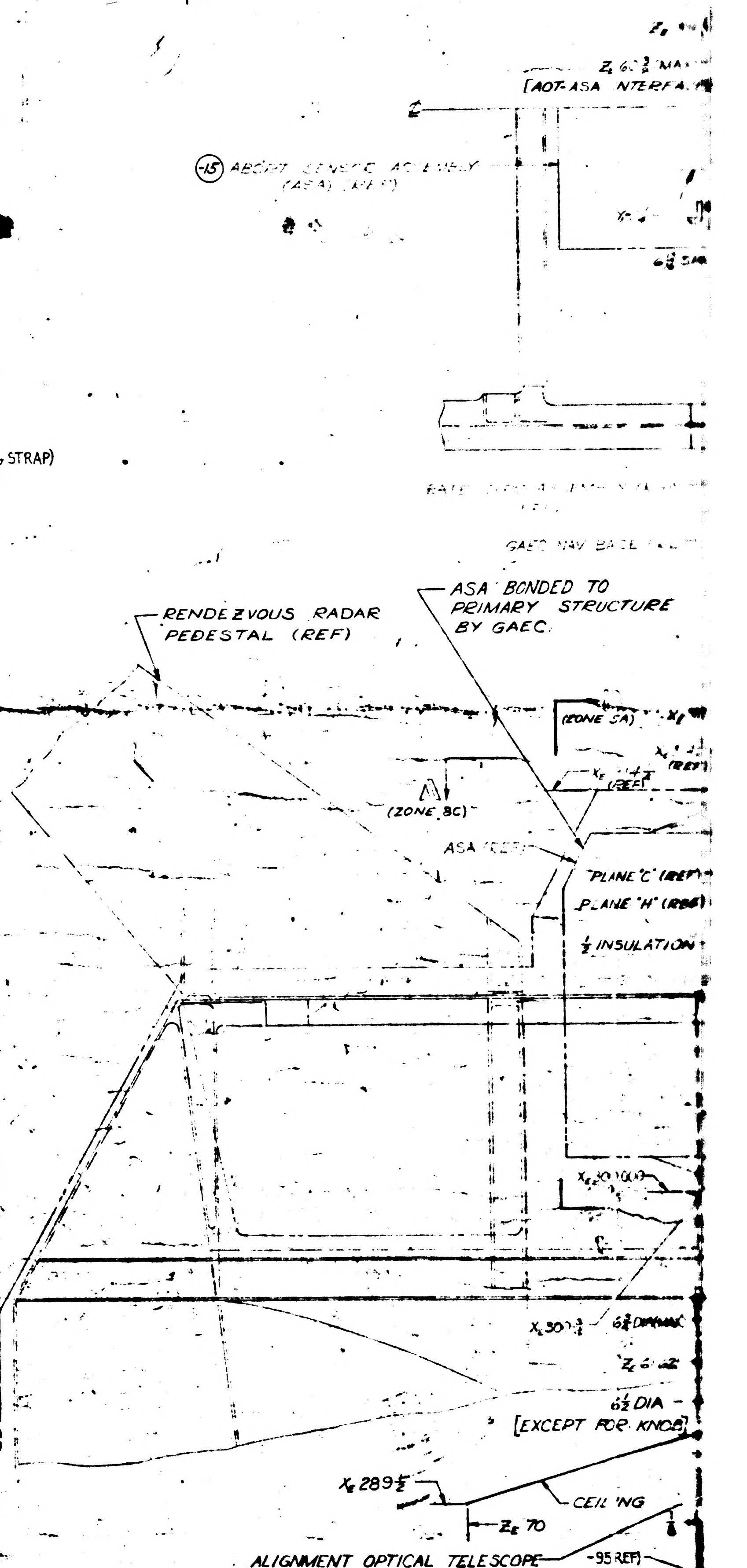
F1 1004A


PLANE "A"
11 B .0015
— .0005
F F (ZONE 13B)
Z_E 55.250
G G (ZONE 13A)
PLANE B DATUM
PLANE H 11 K .0005
H H (ZONE 13B)
PLANE "C" 11 H .0005 — .0002

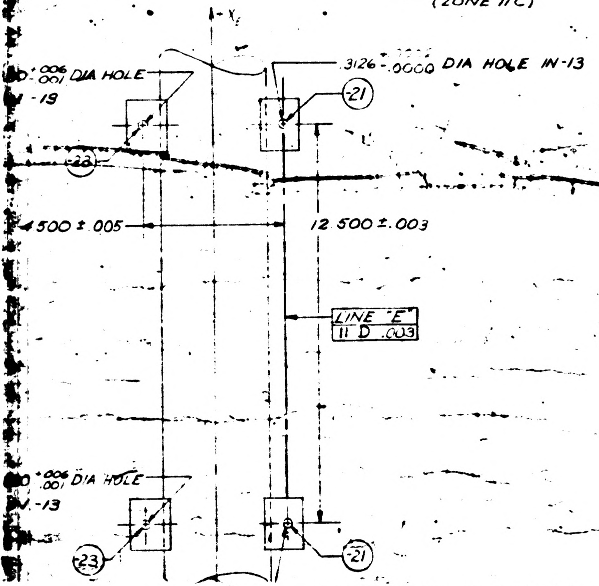
SECT E-E
(ZONE 11C)


17
MIT NAV BASE
E E (ZONE 13C)
NAV BASE MOUNT (LINE)
15 1/4 MAX DIA MIT NAV BASE
NAV BASE MOUNT (FIXED)(REF)
GAEC NAV BASE
M M (ZONE 12A)
S S (ZONE 3A)
X_E 310.422 (REF)
X_E 309 3/8
7/8
Y_E 5 3/8
19
THERMAL SHIELD
5/8
8 5/16
11 1/2
X_E 301 3/32
Y_E 15/16
-97 REF (BONDING STRAP) (SEE ZONE 25A SHC)
1/8 MIN CLEAR (TYP)
P (ZONE 4A)
AF (ZONE 25A)
NAV BASE MOUNT (PLANE) (REF)
Y_E 0
RGA (REF)

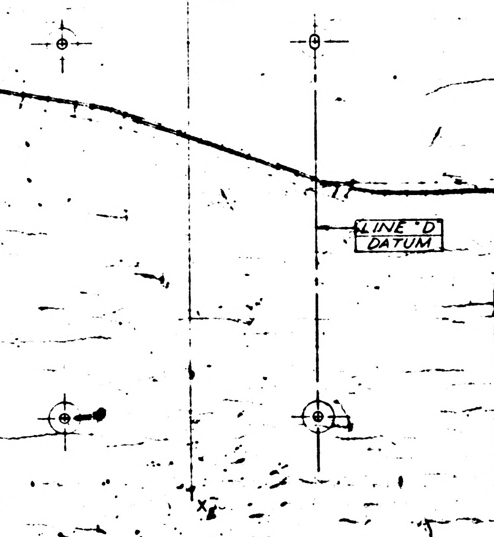
SECT C-C (ZONE 8B)


Z_E 60 3/8 MAX
[AOT-ASA INTERFACE
-15 ABORT SENSOR ASSEMBLY (ASA) (REF)
6 3/8 SM
GAEC NAV BASE
RENDEZVOUS RADAR PEDESTAL (REF)
ASA BONDED TO PRIMARY STRUCTURE BY GAEC.
(ZONE 5A)
A (ZONE 8C)
ASA (REF)
PLANE "C" (REF)
PLANE "H" (REF)
1/4 INSULATION
X_E 301 3/8
6 3/8 DIA MAX
6 1/2 DIA
[EXCEPT FOR KNOB]
X_E 289 1/2
CEILING
Z_E 70
ALIGNMENT OPTICAL TELESCOPE (AOT)
-95 REF)
1/2
3/4 R
X_E 284
RETICLE DIMMER KNOB
ENVELOPE

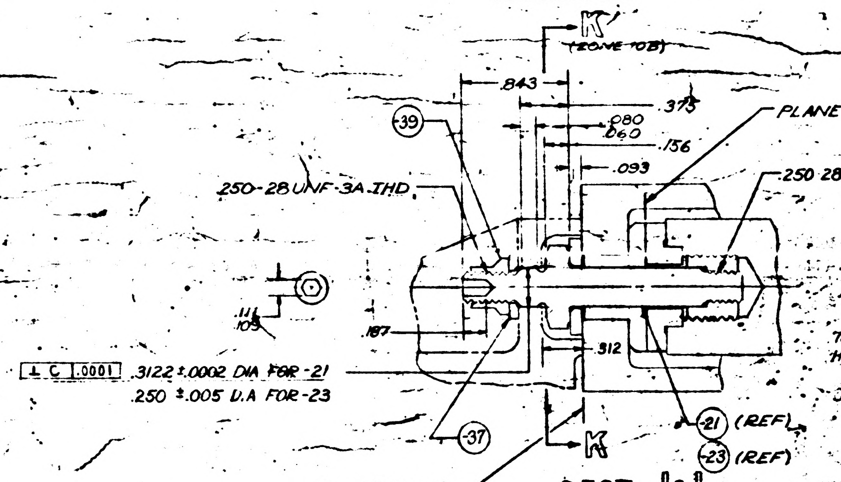
VIEW LOOKING ALONG


.3126 +.0006 -.0000 DIA HOLE IN -13
.006 .001 DIA HOLE -19
21
28
4.500 ± .005
12.500 ± .003
LINE "E" 11 D .003
.006 .001 DIA HOLE -13
23
21
.3126 +.0006 -.0000 DIA HOLE IN -13

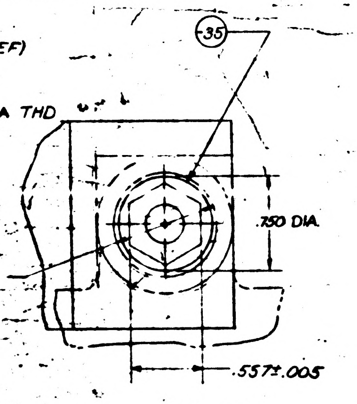
SECT H-H
(ZONE 13C)


LINE "D" DATUM

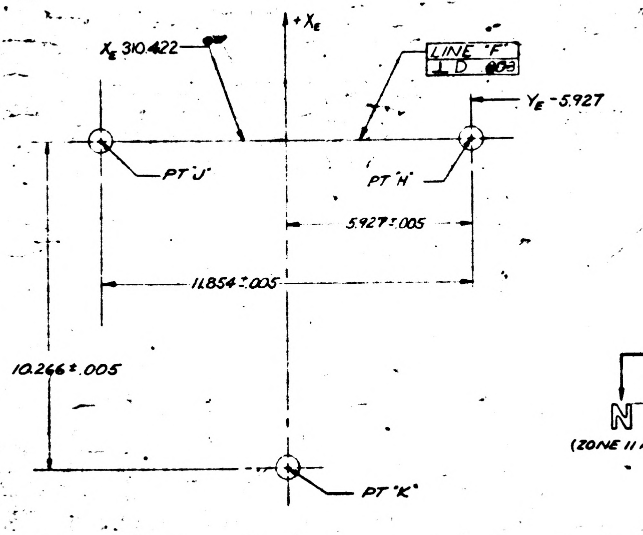
SECT F-F
(ZONE 13C)


K (ZONE 10B)
.843
.080 .060
.375
.156
.093
PLANE "H" (REF)
39
.250-28UNF-3A THD
.250 28UNF-3A THD
.187
.312
.111 .109
⊥ C .0001 .3122 ± .0002 DIA FOR -21
.250 ± .005 DIA FOR -23
37
K
21 (REF)
23 (REF)
PLANE "C" (REF)

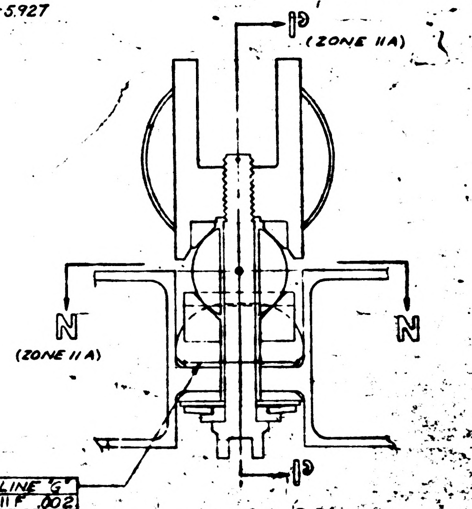
SECT J-J
(TWICE SIZE) (ZONE 8C)


35
.750 DIA
.781 DIA IN -15
.557 ± .005

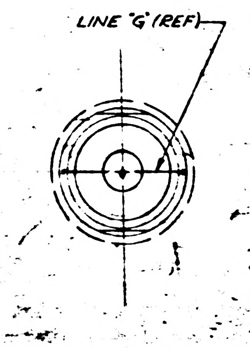
SECT K-K
(TWICE SIZE) (ZONE 11B)


+X_E
X_E 310.422
LINE "F" ⊥ D .003
Y_E -5.927
PT "J"
PT "H"
5.927 ± .005
11.854 ± .005
10.266 ± .005
PT "K"

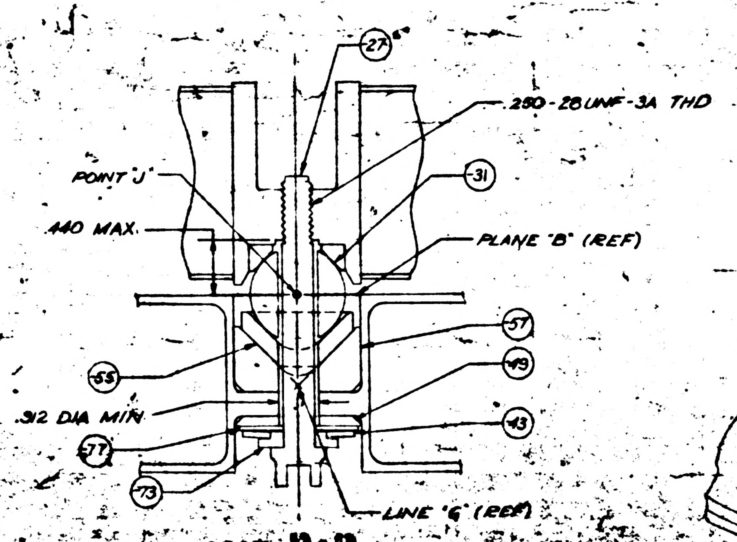
SECT G-G
(ZONE 13C)


P (ZONE 11A)
N N
(ZONE 11A)
P
LINE "G" 11 F .002

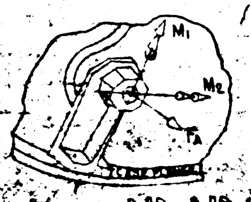
SECT M-M
(TWICE SIZE) (ZONE 11C)



SECT N-N
(TWICE SIZE) (ZONE 12A)


27
.250-28UNF-3A THD
POINT "J"
31
.440 MAX
PLANE "B" (REF)
57
49
55
43
.312 DIA MIN
77
73
LINE "G" (REF)

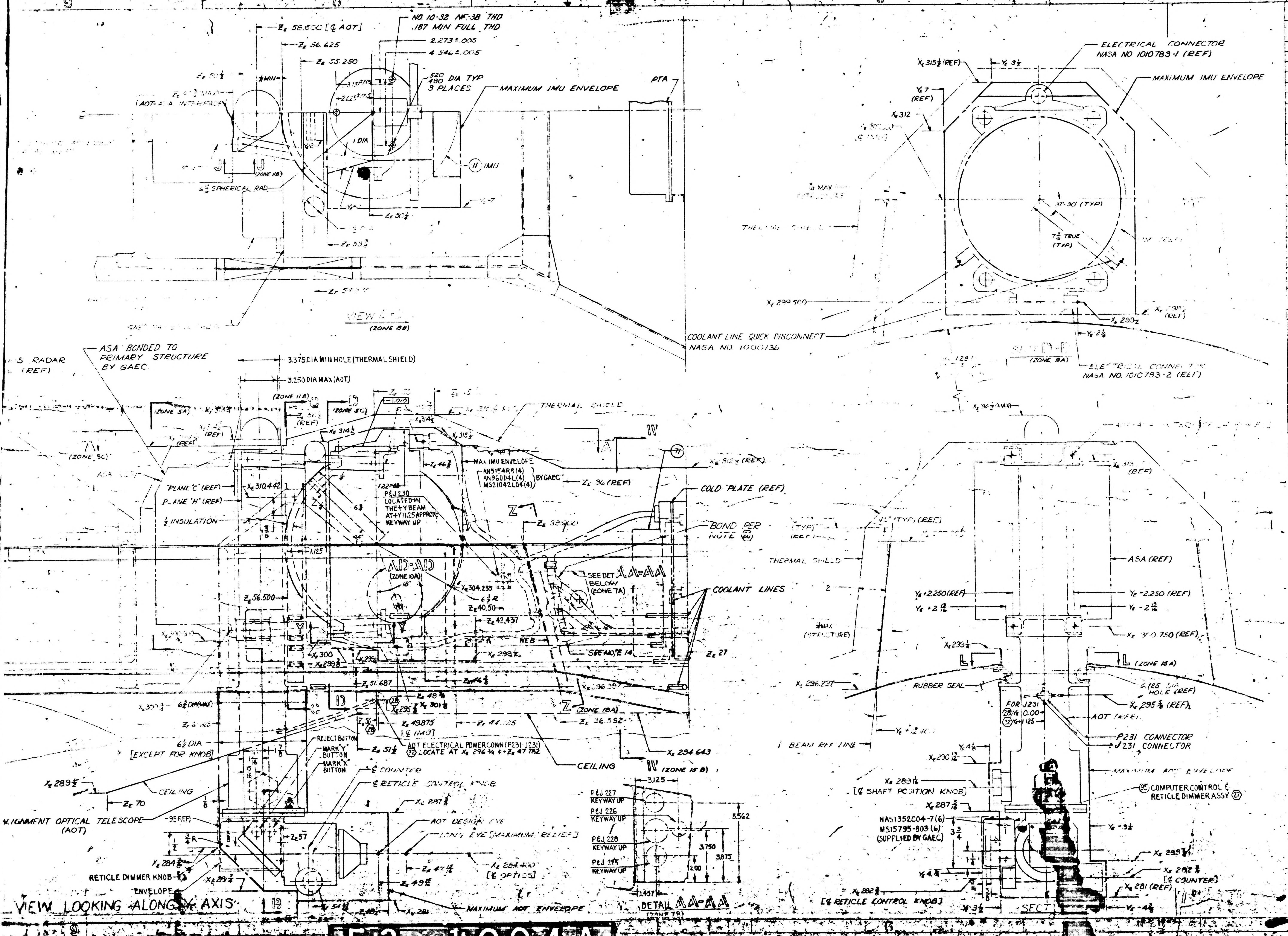
SECT P-P
(TWICE SIZE) (ZONE 12A)



VIEW AD-AD
NO SCALE (ZONE 8B)

MAXIMUM VALUES OF DYNAMIC LOAD		
M1	M2	FA
12.3 IN.LBF	27.7 IN.LBF	16.7 IN.LBF

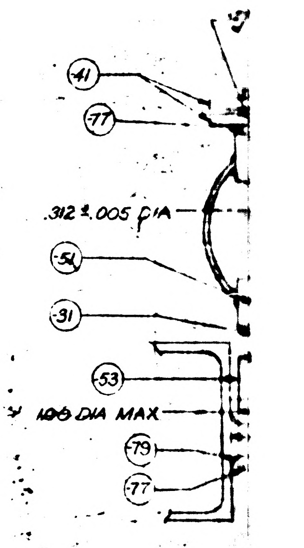
THESE VALUES RESULT IN STRESSES AT THE ENDURANCE LIMIT OF THE IMU CASE

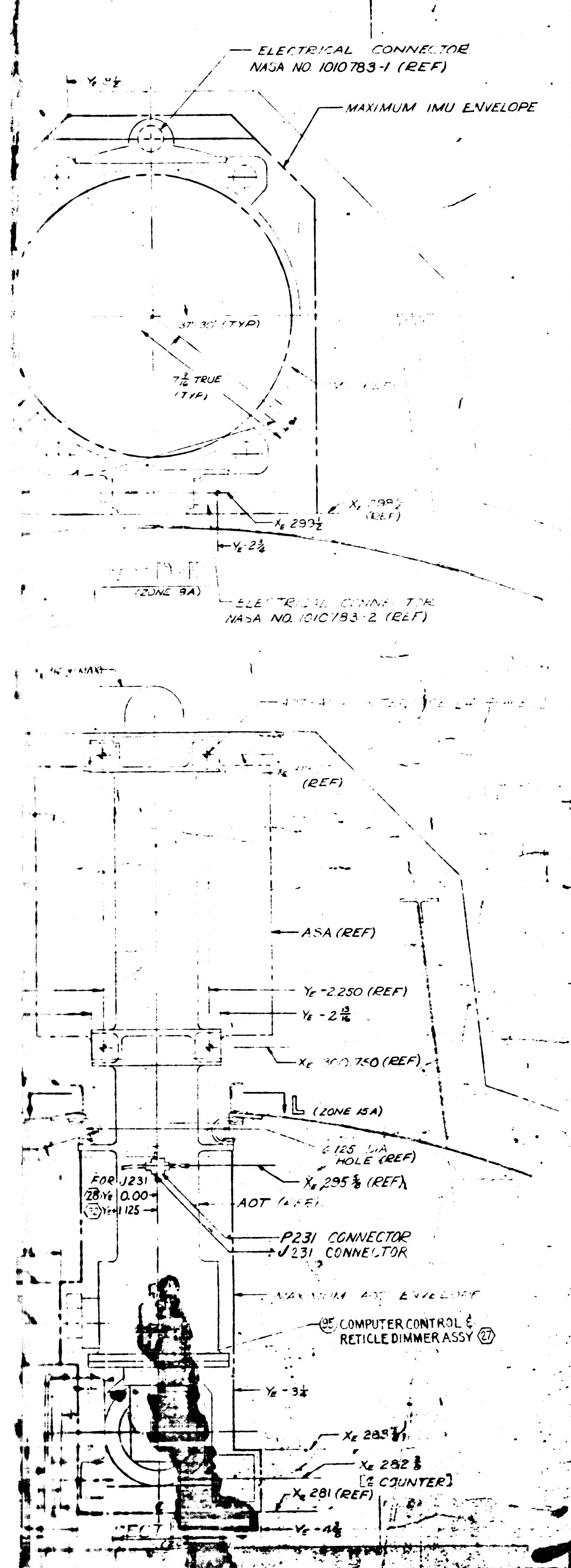

9
8
6
5
NO. 10-32 NF-3B THD
.187 MIN FULL THD
2.273 ±.005
4.546 ±.005
.520 / .480 DIA TYP
3 PLACES
MAXIMUM IMU ENVELOPE
Z_E 58.500 [¢ AOT]
Z_E 56.625
Z_E 55.250
AOT-ASA INTERFACE
$6\frac{1}{2}$ SPHERICAL RAD
1 DIA
-11 IMU
PTA
Z_E $50\frac{1}{2}$
Z_E $53\frac{3}{8}$
VIEW
(ZONE 8B)
ELECTRICAL CONNECTOR
NASA NO 1010783-1 (REF)
MAXIMUM IMU ENVELOPE
X_E $315\frac{1}{2}$ (REF)
Y_E $3\frac{1}{2}$
Y_E 7 (REF)
X_E 312
37°30' (TYP)
$7\frac{1}{2}$ TRUE (TYP)
THERMAL SHIELD
X_E 299.500
X_E $299\frac{1}{2}$
Y_E $2\frac{1}{4}$
COOLANT LINE QUICK DISCONNECT
NASA NO 1000136
(ZONE 8A)
ELECTRICAL CONNECTOR
NASA NO. 1010783-2 (REF)
S RADAR (REF)
ASA BONDED TO
PRIMARY STRUCTURE
BY GAEC
3.375 DIA MIN HOLE (THERMAL SHIELD)
3.250 DIA MAX (AOT)
(ZONE 11B)
(ZONE 5A)
(ZONE 5C)
(ZONE 9C)
X_E $314\frac{1}{2}$
X_E $315\frac{1}{2}$
THERMAL SHIELD
MAX IMU ENVELOPE
AN515488 (4)
AN960D4L (4)
MS21042L04 (4)
BY GAEC
Z_E 36 (REF)
X_E $312\frac{3}{4}$ (REF)
COLD PLATE (REF)
BOND PER NOTE 20
PLANE 'C' (REF)
PLANE 'H' (REF)
$\frac{1}{2}$ INSULATION
X_E 310.442
P&J 230
LOCATED IN
THE +Y BEAM
AT +Y 11.25 APPROX
KEYWAY UP
Z_E 38.900
AD-AD
(ZONE 10A)
SEE DET AA-AA
BELOW
(ZONE 7A)
COOLANT LINES
Z_E 56.500
X_E 304.235
$6\frac{3}{4}$ R
Z_E 40.50
Z_E 42.437
WEB
X_E 300
X_E $298\frac{1}{2}$
SEE NOTE 14
Z_E 27
Z_E 51.687
X_E 296.287
Z_E $48\frac{7}{8}$
X_E $301\frac{1}{2}$
Z_E 49.875
Z_E 44.125
(ZONE 18A)
Z_E 36.592
¢ IMU
AOT ELECTRICAL POWER CONN (P231-J231)
LOCATE AT X_E $296\frac{3}{4}$ & Z_E 47.782
X_E 294.643
$6\frac{1}{2}$ DIA
[EXCEPT FOR KNOB]
REJECT BUTTON
MARK 'Y' BUTTON
MARK 'X' BUTTON
¢ COUNTER
¢ RETICLE CONTROL KNOB
CEILING
(ZONE 15 B)
X_E $289\frac{1}{2}$
CEILING
Z_E 70
ALIGNMENT OPTICAL TELESCOPE (AOT)
X_E $287\frac{1}{4}$
AOT DESIGN EYE
LONG EYE [MAXIMUM RELIEF]
X_E 284.400
[¢ OPTICS]
Z_E 57
X_E $284\frac{3}{8}$
RETICLE DIMMER KNOB
ENVELOPE
Z_E $47\frac{1}{4}$
Z_E $49\frac{1}{2}$
MAXIMUM AOT ENVELOPE
VIEW LOOKING ALONG Y_E AXIS
3.125
P&J 227 KEYWAY UP
P&J 226 KEYWAY UP
P&J 228 KEYWAY UP
P&J 225 KEYWAY UP
5.562
3.750
3.875
2.00
1.437
DETAIL AA-AA
(ZONE 7B)
X_E $316\frac{1}{2}$ (MAX)
X_E 315 (REF)
THERMAL SHIELD
ASA (REF)
Y_E +2.250 (REF)
Y_E $+2\frac{13}{16}$
Y_E -2.250 (REF)
Y_E $-2\frac{13}{16}$
X_E 300.750 (REF)
X_E $299\frac{1}{2}$
L
(ZONE 15A)
X_E 296.287
RUBBER SEAL
.6125 DIA HOLE (REF)
X_E $295\frac{3}{8}$ (REF)
FOR J231
Y_E 0.00
Y_E 1.125
AOT (REF)
BEAM REF LINE
P231 CONNECTOR
J231 CONNECTOR
X_E $290\frac{13}{16}$
MAXIMUM AOT ENVELOPE
X_E $289\frac{1}{4}$
[¢ SHAFT POSITION KNOB]
COMPUTER CONTROL & RETICLE DIMMER ASSY 27
X_E $287\frac{3}{8}$
NAS1352C04-7 (6)
MS15795-803 (6)
(SUPPLIED BY GAEC)
Y_E $-3\frac{1}{2}$
X_E $285\frac{1}{2}$
X_E $282\frac{3}{8}$
[¢ COUNTER]
X_E 281 (REF)
X_E $282\frac{3}{8}$
[¢ RETICLE CONTROL KNOB]
Y_E $-4\frac{3}{4}$
SECT

DASH NO.	DESCR
11	INERTIAL MEAS
13	ALIGNMENT OPT
15	ABORT SENS
17	NAVIGATION
19	NAVIGATION BASE
21	STUD-AOT
23	STUD-AOT AL
25	BOLT-NAV BASE
27	BOLT-NAV BALL
29	BOLT-NAV BALL
31	BALL
33	CONE INSERT
35	WASHER-OLA
37	WASHER-ASA
39	NUT-ASA
41	SPRING WASHER
43	SPRING WASHER
45	WASHER NB
47	SPACER-NB
49	WASHER-NB
51	[illegible]
53	CONE FLAT
55	CONE VEE
57	GROOVE
59	SEAL
61	PLATE
63	PLATE-SEAL
65	DOUBLER SEAL
67	SCREW-AOT
69	SCREW-
71	FUSE TORQUE
73	SPACER NB
75	WASHER-BOLT NB
77	PLATE BOLT
79	PLATE WASHER
81	PLATE NB FLAT
83	ELECTRICAL
85	COLD PLATE-PTA
87	COMPUTER CONT & RETIC
89	AOT GUARD
91	WASHER-N/B-AOT
93	WASHER-N/B-AOT
95	COMPUTER CONT
97	STRAP-BONDING

NOTES: (CONTINUED)

24 24. EFFECTIVITY FOR
25 25. EFFECTIVITY: LM-3
26 26. EFFECTIVITY
27 27. EFFECTIVITY: LM
28 28. EFFECTIVITY
29 29. EFFECTIVITY: LM
30 30. EFFECTIVITY: LM-
31 31. EFFECTIVITY: LM
32 32. EFFECTIVITY


-41
-77
.312 ±.005 DIA
-51
-31
-53
1.00 DIA MAX
-79
-77

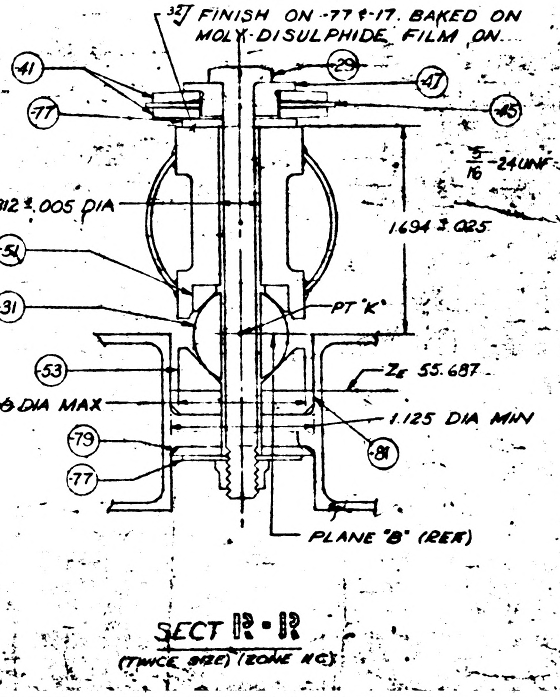


LIST OF AFFECTED PARTS

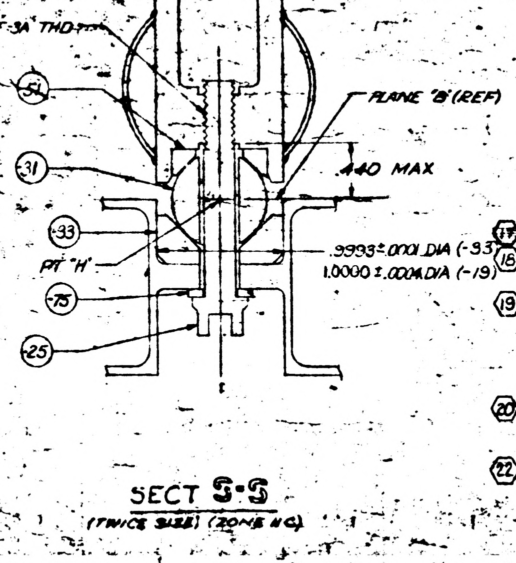
DASH NO.	DESCRIPTION	NO REQ'D / INSTAL	MATERIAL	EFFECTIVITY	SUPPLIER	NOTES
11	INERTIAL MEASURING UNIT	1	—	SEE NOTE (26)	MIT	
13	ALIGNMENT OPTICAL TELESCOPE	1	BE		MIT	
15	ABORT SENSOR ASSEMBLY	1	BE		GAEC	
17	NAVIGATION BASE	1	AL		MIT	
19	NAVIGATION BASE MOUNT	1	AL		GAEC	
21	STUD-AOT	2	TI		MIT	
23	STUD-AOT ALIGNMENT	2	TI		MIT	
25	BOLT-NAV BASE FIXED	1	TI		GAEC	NAS 1272-18
27	BOLT-NAV BASE VEE	1	TI		GAEC	NAS 1271-24
29	BOLT-NAV BASE FLAT	1	TI		GAEC	NAS 674 V46
31	BALL	3	CHR STL		GAEC	MAKE FROM MS19059-65
33	CONE INSERT NB FIXED	1	CHR STL		GAEC	
35	WASHER - OUA	4	STL		MIT	
37	WASHER - ASA	4	STL		GAEC	
39	NUT - ASA	4	TI		GAEC	SPS P/N FNT20-428
41	SPRING WASHER NB PLANE	2	STL		GAEC	
43	SPRING WASHER NB VEE	1	STL		GAEC	
45	WASHER NB PLANE	2	STL		GAEC	
47	SPACER - NB PLANE	1	STL		GAEC	
49	WASHER - NB VEE	1	STL		GAEC	
51	CONE INSERT NB	3	CHR STL		MIT	
53	CONE FLAT NB SUPT	1	CHR STL		GAEC	
55	CONE VEE NB SUPT	1	CHR STL		GAEC	
57	GROOVE INSERT NB SUPT	1	CHR STL		GAEC	
59	SEAL BOOT AOT	1	FLUOR. SILICONE		MIT	
61	PLATE SEAL AOT	1	BE		MIT	
63	PLATE - SEAL STRUCT	1	AL		GAEC	
65	DOUBLER - SEAL STRUCT	1	AL		GAEC	
67	SCREW - AOT	12	STL		MIT	
69	SCREW - STRUCTURE	12	STL		GAEC	GS550A-632
71	PULSE TORQUE ASSEMBLY	1	AL		MIT	
73	SPACER NB VEE	1	STL		GAEC	
75	WASHER-BOLT NB FIXED	1	AL		GAEC	
77	PLATE BOLT	2	STL		GAEC	
79	PLATE-WASHER NB FLAT	1	STL		GAEC	
81	PLATE NB FLAT	1	STL		GAEC	
83	ELECTRICAL JUNCTION BOX	1	—		MIT	
85	COLD PLATE-PTA	1	AL	SEE NOTE (26)	GAEC	
87	COMPUTER CONT & RETICLE DIMMER ASSY	1	AL	SEE NOTE (25)	MIT	
89	AOT GUARD	1	AL	SEE NOTE (31)	GAEC	
91	WASHER-NVB-AOT	2	TI	LTA-3	MIT	
93	WASHER-NVB-AOT	2	TI	LTA-3	MIT	
95	COMPUTER CONT & ~~RETICLE DIMMER ASSY~~	1	AL	SEE NOTE (27)	MIT	
97	STRAP-BONDING	1	AL	SEE NOTE (26)	MIT	

NOTES: (CONTINUED)

(24) 24. EFFECTIVITY FOR THIS ICD IS: ESI, LTA-1, LTA-1R. LTA-3, LTA-8, ~~LM-1~~ THRU LM-15
(25) 25. EFFECTIVITY: LM-3 & SUBQ
(26) 26. EFFECTIVITY: ESI, LTA-1, LTA-1R, LTA-3, LTA-8, LM-1 THRU LM-15
(27) 27. EFFECTIVITY: ESI, LTA-1, LTA-1R, LTA-3, LTA-8, LM-1 & LM-2
(28) 28. EFFECTIVITY: ESI, LTA-1, LTA-1R, LTA-8, LM-1 & LM-2
(29) 29. EFFECTIVITY: LM-1 THRU LM-15
(30) 30. EFFECTIVITY: LM-1, LM-2 & LM-3
(31) 31. EFFECTIVITY: LM-2 THRU LM-15
(32) 32. EFFECTIVITY: LTA-3, LM-3 THRU LM-15



SECT R-R
(TWICE SIZE) (ZONE 4C)



SECT S-S
(TWICE SIZE) (ZONE 4C)

NOTES

1- THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES EFFECTED HEREIN

2- INTERPRET DRAWINGS IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327

3- ALL DIMENSIONS ARE IN INCHES. TOLERANCES UNLESS OTHERWISE SPECIFIED ARE: FRACTIONS ± 1/16, DECIMALS ± .010 ANGLES ± 30'

4- ALL DIMENSIONS AND PRELOADS MUST BE WITHIN SPECIFIED LIMITS AT A UNIFORM PART TEMPERATURE OF 65°-75°F

5 (A) BOLTS ATTACHING -11 (IMU) TO -17 (NAV BASE) ARE TO BE INSTALLED WITH SUFFICIENT TORQUE TO INSURE A MINIMUM PRELOAD OF 700 LBS. PER BOLT

(B) -21 & -23 (AOT STUDS) ATTACHING -13 (AOT) TO -17 (NAV BASE) ARE TO BE INSTALLED WITH SUFFICIENT TORQUE TO INSURE A MINIMUM PRELOAD OF 2200 LBS. PER STUD.

(C) -39 (ASA NUTS) ATTACHING -15 (ASA) TO -13 (AOT) ARE TO BE INSTALLED WITH A TORQUE OF 35-40 IN-LBS (2200 # PRELOAD)

(D) -25 (BOLT @ CONE) IS TO BE INSTALLED WITH A TORQUE OF 170-180 IN-LBS (6500 LB PRELOAD)

(E) -27 (BOLT @ VEE) WILL BE PRELOADED TO 310 ± 75 LBS BY COMPLETELY FLATTENING -43 (SPRING WASHER) BETWEEN -73 (SPACER) & -77 (WASHER) AND THEN BACKING OFF -27 BOLT HEAD .005 ± .002 ALONG -27 ℄ RELATIVE TO -77.

(F) -29 (BOLT @ PLANE) WILL BE PRELOADED TO 1050 ± 150 LBS BY COMPLETELY FLATTENING -41 (SPRING WASHERS) BETWEEN -47 (SPACER) AND -77 (WASHER) AND THEN BACKING OFF -29 BOLT HEAD .006 ± .002 ALONG -29 ℄ RELATIVE TO -77.

6- THE FOLLOWING SURFACES ARE TO BE LAPPED TOGETHER TO A 8J TO 12J FINISH AND THEN COATED WITH A BAKED ON MOLY-DISULPHIDE FILM PER LSP14-10300:

(A) -53 TO -81
(B) -79 TO -77
(C) -55 TO -57
(D) -49 TO -77

7- THE FOLLOWING SURFACES ARE TO HAVE FINISHES AND HARDNESSES AS FOLLOWS AT INTERFACE SURFACES WITH OTHER PARTS ON THIS LIST:

PART	MATING SURFACE	FINISH	HARDNESS
-31 (BALLS)	(ENTIRE SPHERE)	4J	C60-C67
-51 (NB CONES)	-31	10J - 16J	C58-C62
-33 (CONE FIXED)	-31	10J - 16J	C58-C62
-53 (CONE PLANE)	-31 & -19	10J - 16J	C58-C62
-55 (CONE VEE)	-31 & -57	10J - 16J	C58-C62
-57 (VEE)	-55	SEE NOTE #6	C58-C62
-63 (SEAL PLATE)	-59	32J	—
-65 (SEAL DBLR)	-59	32J	—
-15 (ASA)	-13	32J	—
-13 (AOT)	15	32J	—

8- THE INSULATION ON -11 (IMU) MAY BE LOCALLY COMPRESSED BY -19 (NAV BASE SUPPORT) TO A MAXIMUM OF 25% OF INSULATION THICKNESS

9- -13 (AOT) TO BE INSTALLED SO THAT CENTER OF SEAL BOOT MOUNTING HOLE PATTERN IN -13 IS TO BE WITHIN .062 OF CENTER OF HOLE PATTERN IN -65 (SEAL DOUBLER) AND ARE TO REMAIN WITHIN .250 OF EACH OTHER UNDER THERMAL, PRESSURE AND VIBRATION ENVIRONMENT

10- -59 (AOT SEAL) IS TO BE INSTALLED SO THAT SEAL IS COMPRESSED .020 $^{+.005}_{-.000}$ BETWEEN -63 (SEAL PLATE) AND -65 (SEAL DOUBLER).

11- LEAKAGE THRU BARREL OF -13 (AOT), DIFFUSION THRU -59 (SEAL), AND LEAKAGE THRU THE FAYING SURFACES OF -13 TO -59 & -61 TO -59 SHALL NOT EXCEED A TOTAL OF 1×10^{-4} LBS. O_2/HR OVER A TEMPERATURE RANGE OF -30°F TO +200°F AND UNDER LOAD CONDITIONS SPECIFIED IN LIS 520-10001.

12- EACH DELIVERABLE ITEM SHALL BE CONSIDERED ACCEPTABLE FOR PHYSICAL DIMENSIONS OF THE INTERFACE WHEN INSPECTED BY NASA AND FOUND TO BE IN AGREEMENT WITH THE DIMENSIONS AS SPECIFIED ON THIS DRAWING.

13. AOT BUTTON BOX CONFIGURATION AND ELECTRICAL JUNCTION BOX CONFIGURATION WILL BE INCORPORATED BY "IRN".

14. PART NUMBERS ARE SHOWN FOR REFERENCE ONLY

15. LID-390-10001 CONTROLS INTRA-SYSTEM WIRING AND INTERFACE CONNECTORS.

~~16. GAEC WILL PROVIDE STRUCTURE TO PROTECT AOT MOUNT BUTTON BOX~~

(17) ~~17. DESIGN DATA REQUIRED~~

(18) 18. THERMAL INTERFACE MATERIAL (RTV 601-FILLED 25% BY WT. 325 MESH Al_2O_3) TO BE APPLIED PER LSP14-22601A BETWEEN PTA & COLD PLATE.

(19) 19. BONDING DC RESISTANCE ACROSS METALLIC SURFACES SHALL BE 10 MILLIOHMS OR LESS. THESE SURFACES SHALL BE TEMPORARILY PROTECTED BY APPLYING A COAT OF MIL-C-16173 GRADE 4 CORROSION COMPOUND. ALUMINUM SURFACES TREATED PER MIL-C-5541 WITH ALODINE 1200S, NEEDS NO PROTECTION.

(20) 20. THE DC RESISTANCE BETWEEN THE BOLTED CONNECTOR HALF AND THE VEHICLE STRUCTURE SHALL BE LESS THAN 100 MILLIOHMS

21. -31 (BALL) TO BE SILVER PLATED PER QQ-S-365 TYPE I (.0005 MIN-REF)

(22) 22. EACH CLAMP USED FOR HARNESS "B" COMES INDIVIDUALLY MARKED WITH AN ALPHABETICAL CHARACTER (J, K, L, M, N OR P) AS A REF DESIGNATION AND MUST BE INSTALLED AT THE LOCATION REFERENCED IN THE FIELD OF DRAWING. ALPHABETICAL MARKINGS TO BE REMOVED AFTER CLAMPS ARE INSTALLED

23. NAVIGATION BASE VIBRATION INSTRUMENTATION INSTL IS DEFINED & CONTROLLED BY LIS-370-10003.

IRN NO.	CN NO.	ZONE	DESCRIPTION OF REVISION	EFFECTIVITY
-1	1	8B	ADDED VIEW AD-AD & TABLE OF LOAD VALUES	
-2	1	2A	ADDED NOTE 23	
-3	1	2C	REVISED NOTE [illegible]	
		2A	ADDED LSP14-22601A TO NOTE 18 & ADDED NOTE 21	
		3A	SECT S-S: 5/16-24 UNF-3A WAS .250-28 UNF 3A	
		3C	PARTS LIST: NAS1272-18 WAS 1271-18 & ADDED -[illegible]	
		7A	VIEW ALONG YE AXIS: REV. SEE WIRE HARNESS, CLAMPING & DISCONNECT BKT -REMOVED CONN LOCATION TABLE-ADDED CONN LOCATIONS ON DISCONNECT BKT & DET AA-AA-RELOCATED RECEPTACLE J230	
		15B	-85 WAS STRUCTURE (4 PLACES) IN SECT W-W	
		17A	VIEW Z-Z: ADDED -83 ENVELOPE & MTG DIMS, MECHANICAL INTERFACE DIMS & NAS1133V5(4)	
		17A 17B	VIEW X-X & Z-Z: REVISED WIRE HARNESS, CLAMPING & DISCONNECT BKT - ADDED CLAMP MTG HARDWARE	
		11C	SECT C-C: YE 15/16 WAS YE 1-3/4, XE 301-3/32 WAS XE 302-1/8 & ADDED ENVELOPE INFO	
		8B	VIEW ALONG YE AXIS: ADDED ENVELOPE INFORMATION FOR -17 & -19	
		11B	SECT J-J: ADDED PERPENDICULARITY REQUIREMENT FOR .3122 DIA ON -21	
-4	1	2A	REVISED NOTE 12 & REMOVED NOTE 16	SEE NOTE 25
	2	21A 23A 21C	ADDED SECT B-B (REF), VIEW LKG ALONG YE AXIS (REF), VIEW AB-AB & ADDED AOT GUARD, (-89) & AOT BUTTON BOX (-87) LOCATION & INTERFACE	
	1	15B	SECT W-W: REVISED -85 (PTA COLD PLATE) HOLE CALLOUTS	
	1	8B	VIEW ALONG YE AXIS: ADDED 3.375 MIN DIA IN THERMAL SHIELD & 3.250 MAX DIA FOR [illegible] COVER	SEE NOTE 26
	1	4B	ADDED NOTE 26 (EFFECTIVITY FOR -11 THRU -85)	
-5	[illegible]	21A	VIEW LKG ALONG YE AXIS (REF): CHANGED DIM. FROM [illegible].97 MIN TO [illegible] MIN	
		21A	SECT B-B (REF): ADDED NOTE: APPLY PROTECTIVE COAT TO FAR SIDE OF GUARD. THICKNESS NOT TO EXCEED .020 IN.	
-6	[illegible]	25A	SECT [illegible] (REF): ADDED -97 BONDING STRAP & INTERFACE DIMS. &	SEE NOTE 26
		24C	ADDED SECT AC-AC; ADDED DET OF -97 & DETAIL AF	LTA-3 ONLY
		25F	SECT J-J (REF): ADDED -91 & -93 (TITANIUM WASHER)	SEE VW X-X
	1	18A	VIEW X-X: DIM. 1.090 WAS 1.030	SEE SE T W-W
		15C	SECT W-W: REVISED HARDWARE CALLOUTS	SEE NOTE 27
		6B 5A	VIEW LKG ALONG YE AXIS & SECT B-B: ADDED -95 (COMPUTER CONT & RETICLE DIMMER ASSY)	
		2A	REMOVED NOTE 17 & ADDED NOTE 22	SEE [illegible]
		6B 17A 17B	VIEW LKG ALONG YE AXIS, VIEW Z-Z & VIEW X-X: REMOVED CABLE SUPPORT, REVISED WIRING & CLAMP & ADDED CLAMP CALLOUTS	
		5A 8B	SECT B-B & VIEW LKG ALONG YE AXIS: REVISED LOCATION OF (P231-J231) AOT CONNECTOR	SEE SECT B-B & VIEW ALONG YE AXIS
		16A	SECT L-L: REMOVED [illegible] DIA HOLES [illegible] FROM -63	
		14A	.130 ± .010 R IN [illegible] WAS .130 ± .005 R	
		4B	FOR EFFECTIVITY OF THIS IRN UNLESS OTHERWISE NOTED SEE NOTE 26	NOTED
-7	1	4B	VEHICLE EFFECTIVITY FOR THIS ICD: SEE NOTE 24	NOTED
-9	1	19A	EFFECTIVITY FOR CLAMP M WAS ESI, LTA-1, LTA-1R, LTA-3, LTA-8, LM-1 [illegible]	NOTED
-8	1	17A	IN VIEW Z-Z REVERSED CLAMP (REF "N")	SEE NOTE 30
-10	1	4B	REVISED EFFECTIVITY OF -89 (AOT GUARD)	SEE NOTE 31
		3B	REVISED NAME OF -87 (WAS AOT BUTTON BOX) CHANGES BY [illegible] - DATE: [illegible]/67	
—	1	6A	REVERSED POSITION OF J231 & P231 CONNECTORS	

REV LTR	DESCRIPTION	AUTHORIZED SIGNATURES	REPRESENTING	DATE
			GAEC	
A	SEE ABOVE	W. Stamesie	MIT	

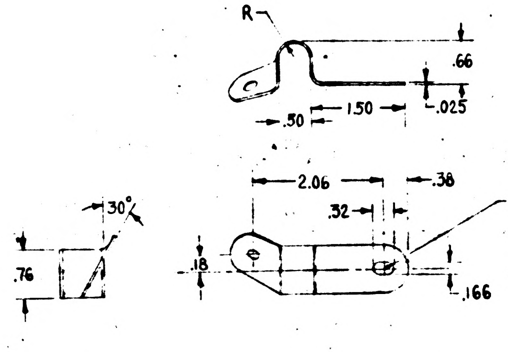
TDRR-346-6
7-29-65

GRUMMAN AIRCRAFT ENGINEERING
BETHPAGE, L. I., N. Y.

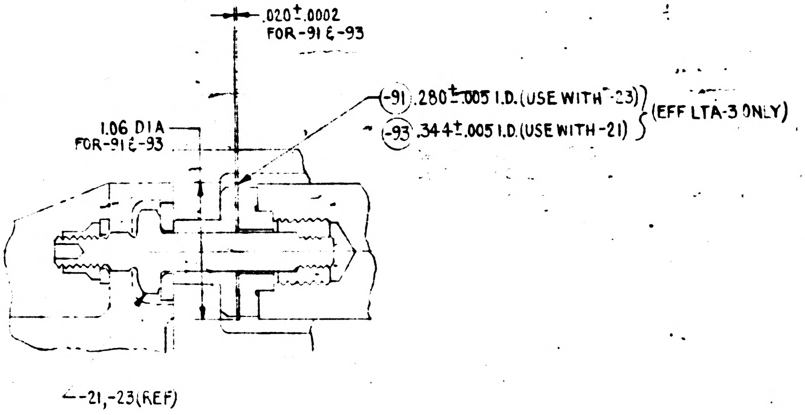
DRAWN BY	Tessmer
LAYOUT BY	
[illegible]	[illegible]

INTERFACE CONTROL
[illegible]

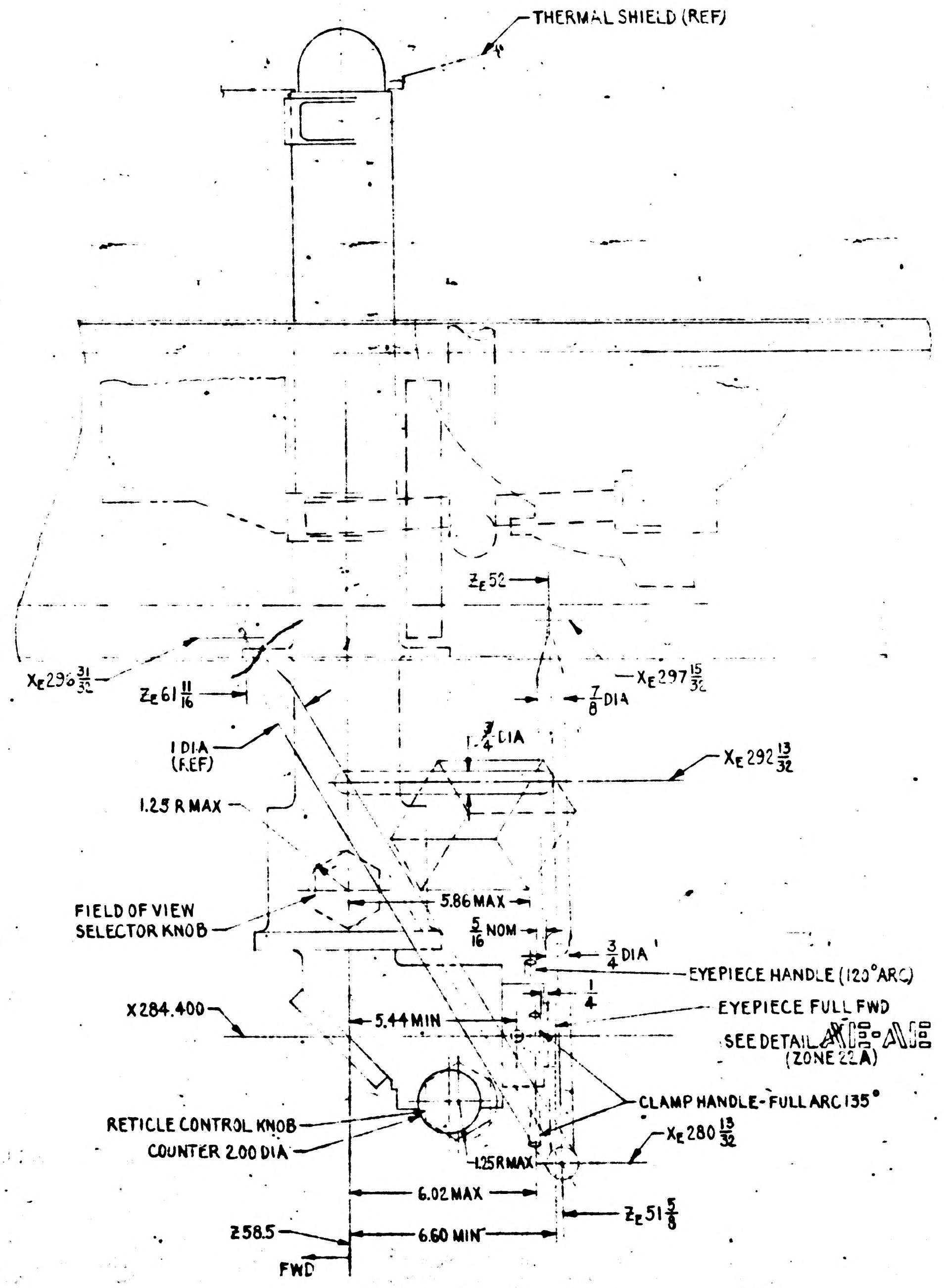
1E4 1004A


R
.66
.025
.50
1.50
2.06
.38
.32
R
30°
.76
.18
.166

DETAIL -97 BONDING STRAP

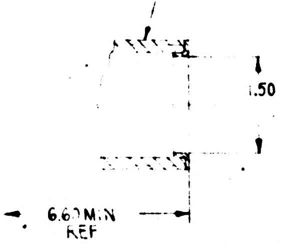

.020 ± .0002
FOR -91 & -93
1.06 DIA
FOR -91 & -93
(-91) .280 ± .005 I.D. (USE WITH -23)
(-93) .344 ± .005 I.D. (USE WITH -21)
(EFF LTA-3 ONLY)
-21, -23 (REF)

SECT J-J (ZONE 11 B SH 1) REF

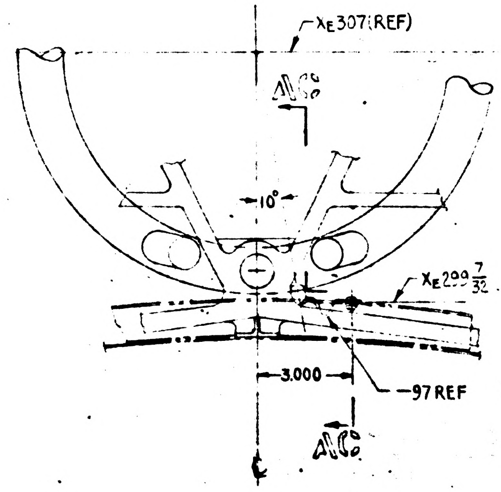

THERMAL SHIELD (REF)
Z_E 52
X_E 296 31/32
Z_E 61 11/16
7/8 DIA
X_E 297 15/32
1 3/4 DIA
1 DIA
(REF)
X_E 292 13/32
1.25 R MAX
5.86 MAX
FIELD OF VIEW
SELECTOR KNOB
5/16 NOM
3/4 DIA
EYEPIECE HANDLE (120° ARC)
1/4
X284.400
5.44 MIN
EYEPIECE FULL FWD
SEE DETAIL AE-AE
(ZONE 22A)
CLAMP HANDLE - FULL ARC 135°
RETICLE CONTROL KNOB
COUNTER 2.00 DIA
X_E 280 13/32
1.25 R MAX
6.02 MAX
Z_E 51 5/8
Z58.5
6.60 MIN
FWD

VIEW LOOKING ALONG Y_E AXIS

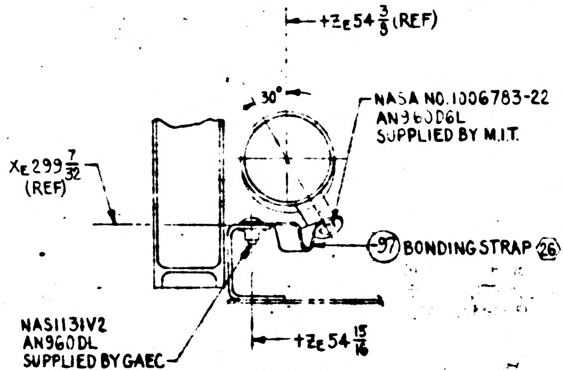
(ZONE 8A SH 1) REF


2-32 UNS-2A
1.50
6.60 MIN
REF

DETAIL AE-AE
(ZONE 23A)


X_E 307 (REF)
AC
10°
X_E 299 7/32
3.000
-97 REF
AC
℄

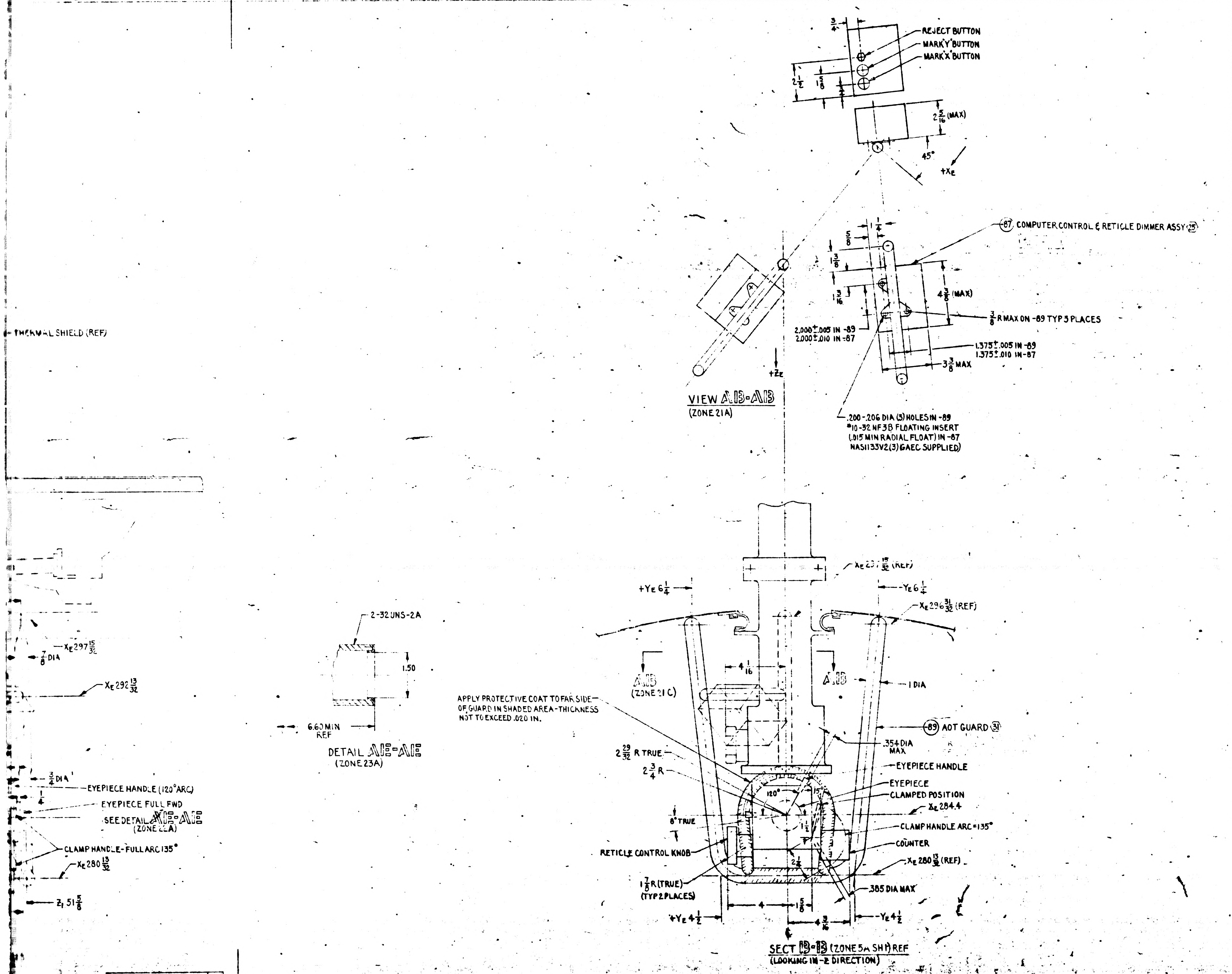
DETAIL AF (ZONE 11 C SH 1) REF


+Z_E 54 3/8 (REF)
30°
NASA NO. 1006783-22
AN960D6L
SUPPLIED BY M.I.T.
X_E 299 7/32
(REF)
(-97) BONDING STRAP (26)
NAS1131V2
AN960DL
SUPPLIED BY GAEC
+Z_E 54 15/16

SECT AC-AC (ZONE 25A)

FULL SCALE

LID280-10004 - SH 2


REJECT BUTTON
MARK'Y' BUTTON
MARK'X' BUTTON
$\frac{3}{4}$
$2\frac{1}{2}$
$1\frac{5}{8}$
$2\frac{5}{16}$ (MAX)
45°
$+X_E$
-87 COMPUTER CONTROL & RETICLE DIMMER ASSY 25
$\frac{5}{8}$
$1\frac{1}{4}$
$1\frac{3}{8}$
$1\frac{3}{16}$
$4\frac{3}{8}$ (MAX)
$\frac{3}{8}$ R MAX ON -89 TYP 3 PLACES
2.000±.005 IN -89
2.000±.010 IN -87
1.375±.005 IN -89
1.375±.010 IN -87
$3\frac{3}{8}$ MAX
$+Z_E$
VIEW AB-AB
(ZONE 21A)
.200-.206 DIA (3) HOLES IN -89
*10-32 NF 3B FLOATING INSERT
(.015 MIN RADIAL FLOAT) IN -87
NAS1133V2(3) GAEC SUPPLIED)
THERMAL SHIELD (REF)
X_E 297 $\frac{15}{32}$
$\frac{7}{8}$ DIA
X_E 292 $\frac{13}{32}$
$\frac{3}{4}$ DIA
$\frac{1}{4}$
EYEPIECE HANDLE (120° ARC)
EYEPIECE FULL FWD
SEE DETAIL AE-AE
(ZONE 22A)
CLAMP HANDLE-FULL ARC 135°
X_E 280 $\frac{13}{32}$
Z_I 51 $\frac{5}{8}$
2-32 UNS-2A
1.50
6.60 MIN
REF
DETAIL AE-AE
(ZONE 23A)
X_E 23? $\frac{15}{32}$ (REF)
$+Y_E$ 6 $\frac{1}{4}$
$-Y_E$ 6 $\frac{1}{4}$
X_E 296 $\frac{31}{32}$ (REF)
$4\frac{1}{16}$
AB
(ZONE 21 C)
AB
1 DIA
APPLY PROTECTIVE COAT TO FAR SIDE OF GUARD IN SHADED AREA-THICKNESS NOT TO EXCEED .020 IN.
-89 AOT GUARD 31
.354 DIA
MAX
$2\frac{29}{32}$ R TRUE
$2\frac{3}{4}$ R
EYEPIECE HANDLE
EYEPIECE
CLAMPED POSITION
120°
15°
X_E 284.4
8° TRUE
$1\frac{1}{2}$
CLAMP HANDLE ARC = 135°
RETICLE CONTROL KNOB
COUNTER
$2\frac{1}{4}$
X_E 280 $\frac{13}{32}$ (REF)
$1\frac{7}{8}$ R (TRUE)
(TYP 2 PLACES)
.385 DIA MAX
4
$1\frac{5}{8}$
$+Y_E$ 4 $\frac{1}{2}$
$-Y_E$ 4 $\frac{1}{2}$
$4\frac{3}{16}$
SECT B-B (ZONE 5A SH 1) REF
(LOOKING IN -Z DIRECTION)

LID280-10004 SH 2

MANUFACTURING OPERATIONS

UNLESS OTHERWISE SPECIFIED
NOTES CHECKED ✓ APPLY TO THIS DWG.

PART NUMBER AND ALL OTHER MARKINGS IN REGION MARKED ▭ USE BOTH SIDES IF NECESSARY.

FILLET AND INSIDE CORNER RADII TOLERANCES
.016R TO .062R ± .010
.063R TO .250R ± .015
OVER .250R ± .030

DEPTH SHOWN FOR TAPPED HOLES IS FULL THDS. 2-3 IMP THDS. BEYOND PERMISSIBLE.

EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.

DO NOT CADMIUM PLATE & PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.

MISMATCH STEP OF ± .005 PERMISSIBLE DUE TO CHANGE OF CUTTERS AT INSIDE INTERSECTING SURFACES.

DIAMETERS MARKED MUST BE CONCENTRIC WITHIN FULL INDICATOR READING

HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.

ALL DIMENSIONS SHOWN TO BE MET AFTER CADMIUM PLATING. THICKNESS OF PLATE .0003 MIN. TO .0005 MAX. MIN. THICKNESS TO BE .0002 ON THREADED AREAS. NO ALLOWANCE FOR PLATING IN HOLES

125 ∇ SURFACE ROUGHNESS INCLUDING REAMED HOLES PER MIL-STD-10

250 ∇ FOR ALL DRILLED HOLES

REMOVE ALL BURRS. BREAK ALL EDGES .015-.031

INSPECTION INFORMATION MINIMUM PERMISSIBLE AVERAGE EDGE DISTANCE MARKED IS

SYMBOL ƒ DENOTES SURFACE TO BE MACHINED

UNLESS OTHERWISE SPECIFIED TOLERANCE ON FLANGES IS ± 1/32

LENGTHS OF AN, NAS & MS AL ALY RIVETS SHORTER THAN 1 INCH ARE NOT SPECIFIED.

TOLERANCE ON LOFTED DELINEATIONS IS

34686 SEP 25 1967

Approved by MIT
W. Stameris 18 Aug 1967

GRUMMAN AIRCRAFT ENGRG CORP., BETHPAGE, L. I., NEW YORK				
SIZE J	CODE IDENT NO. 26512	LID280-10004		A
LM MODEL OR END ITEM	SCALE NOTED		SHEET 2	

TDRK 37655 JUN 17 1969

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	
W.a. Stameris	M.I.T.	9 June 1969

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: LID280-10004A-10
Sheet 1 of 1

ICRA NO: 10-271
Sheet 2 of 2

ICD NO. LID280-10004 Rev. A

CCA NO. **DATE**

ICD TITLE
IMU-ACT-NVB-PTA Instl.

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION: NOTE: This is a revision of IRN Number LID280-10004A-9

1. Revise Note 38 (Ref. Item 4) as follows:

(FROM) 38. All clamps to LM structure mounting hardware for the M.I.T. 'B' harness are to be supplied by GAEC and will consist of the following: For 1010400 clamps (J),(M),(N),(K),(P): GB511J-08 (2), AN960D8L (4), MS21042L08 (2). For 1010705 clamp (L): GB511J-08 (1), AN960D8L (2), MS21042L08 (1). Grip length of GB511J-08 bolts to be determined according to hardware packup and structural thickness.

(TO) 38. Mounting hardware for the "B" harness cable clamps, except clamp (M), shall be supplied by GAEC and will consist of the following: For 1010400 clamps (J),(N),(K),(P): GB511J-08 (2), AN960D8L (4), MS21042L08 (2). For 1010705 clamp (L): GB511J-08 (1), AN960D8L (2), MS21042L08 (1). For 1010400 clamp (M): MS16996-9 (2) (M.I.T. supplied) torqued to 26-29 inch pounds. Grip length of GB511J-08 bolts to be determined according to hardware packup and structural thickness.

EFFECTIVITY OF THIS IRN IS LM1 THROUGH LM15
WS 6/9/69

REASON: Clamp (M) uses M.I.T. supplied fasteners.

DRAWN BY: T. Daly

ENG 37.3 1-64

TDRR 35136 NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J D	GAEC	9/29/67
W. Stameris	MIT/IL	11 Nov 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: LID280-10004 A-1 SHT 1 OF 1

ICRA NO: 10-845 SHT. 2 OF 2

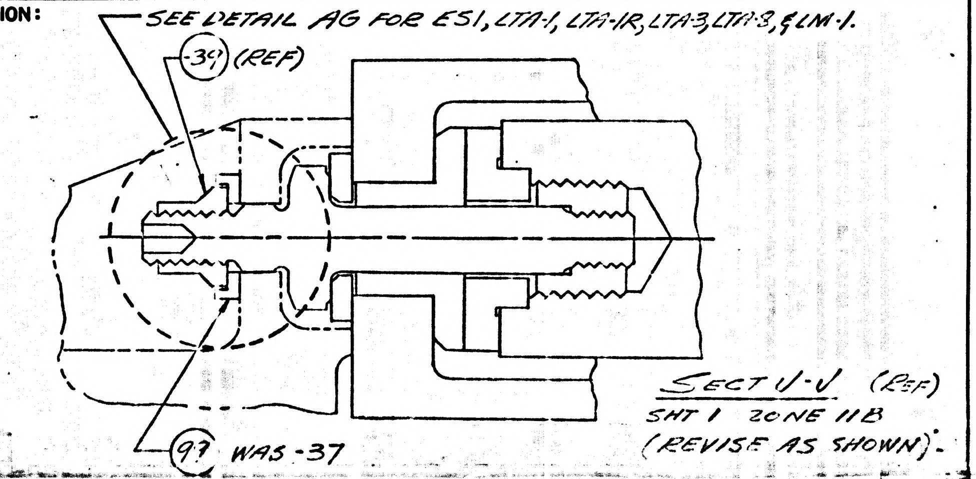
ICD NO. LID280-10004-A

CCA NO. — DATE

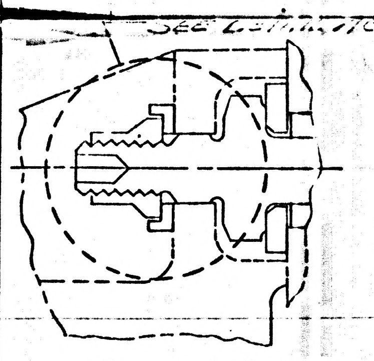
ICD TITLE
IMU-AOT-NVB-PTA
INSTALLATION

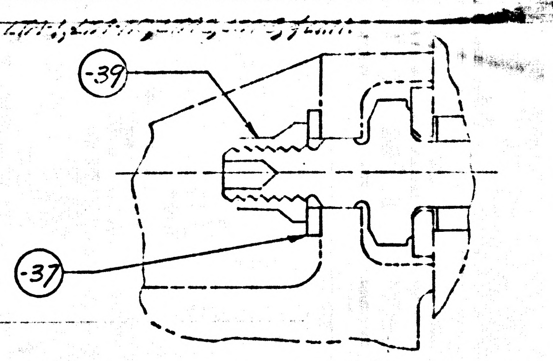
THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:



SECT U-U (REF)
SHT 1 ZONE 11B
(REVISE AS SHOWN).





SECT U-U (REF)
SHT 2 ZONE 25B
(REVISE AS SHOWN)

DETAIL AG (ADD)
(TWICE SIZE)(ZONE 11B & 25B)
FOR ES1, LTA-1, LTA-1R, LTA-3, LTA-8, & LM1

DESCRIPTION OF CHANGE:

1. FOR LM-2 THRU LM-15 REMOVED -37 WASHER-ASA, ADDED -99
2. REVISED SECT U-U (2 PLACES) ADDED DETAIL AG.
3. REVISE "LIST OF AFFECTED PARTS" AS SHOWN BELOW:

	DASH NO.	DESCRIPTION	NO. REQD/INSTL	MATL.	EFFECT.	SUPPLIER
NOW	-37	WASHER-ASA	4	AL	SEE NOTE 33	GAEC
WAS	-37	WASHER-ASA	4	AL	SEE NOTE 26	GAEC
ADD	-99	WASHER-ASA	4	AL	SEE NOTE 31	GAEC

REVISE NOTE 10 AS FOLLOWS: TO INSTALL -59 (AOT SEAL) ON LM-2 THRU LM-15 HAND TIGHTEN SCREWS (2 TO 3 IN. LBS.) THEN COMPRESS SEAL .015 ± .005 BETWEEN -63 (SEAL PLATE) AND -65 (SEAL DOUBLER). FOR OTHER VEHICLES -59 (AOT SEAL) IS TO BE INSTALLED SO THAT SEAL IS COMPRESSED $.020^{+.005}_{-.000}$ BETWEEN -63 (SEAL PLATE) & -65 (SEAL DOUBLER). (WAS) -59 (AOT SEAL) IS TO BE INSTALLED SO THAT SEAL IS COMPRESSED $.020^{+.005}_{-.000}$ BETWEEN -63 (SEAL PLATE) AND -65 (SEAL DOUBLER).

REASON: CHG I: TO INSURE CONCENTRICITY OF ASA WASHER & BOLT LCD7141
CHG II: TO CLARIFY AOT SEAL INSTL. REQUIREMENTS.

DRAWN BY: [illegible]

ENG 37.3 1-66

TDRR 35136 NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J.T. H.	GAEC	11/13/67
W Stameris	MIT/IL	16 Nov 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 EXHIBIT E PARA. 5.6.2
LINE ITEM 13 PRIMARY No. 697 TYPE II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LID280-10004A-2 SHT. 1 OF 1
ICRA NO: 10-240 SHT. 2 OF 2
ICD NO. LID280-10004A
CCA NO. DATE
ICD TITLE IMU-AOT-NVB-PTA INSTALLATION

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

1. FOR -87 IN "LIST OF AFFECTED PARTS" AND FIELD OF DWG ZONE 20D DELETE REFERENCE TO NOTE ㉕, ADD REFERENCE TO NOTE ㉛
2. FOR -95 IN "LIST OF AFFECTED PARTS" AND FIELD OF DWG. ZONE 5A DELETE REFERENCE TO NOTE ㉗, ADD REFERENCE TO NOTE ㉝
3. ADD NOTE ㉝ 33 EFFECTIVITY: ES1, LTA-1, LTA-1R, LTA-3, LTA-8 & LM-1.
4. -37 WASHER-ASH-4-MATL: AL (WAS STL.)
5. -39 NUT-ASA-4-MATL: STL (WAS TI), GN10AJ-428 (WAS SPS P/N FNT20-428)

REASON: 1 THRU 3: CCA651, LCD 1965; 4 & 5: DWG CORRECTION

DRAWN BY: E. STAHL, VDI.

ENG 37.3 1-64

TDRR 25190 JAN 11 1966

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E Stern	GAEC	12/22/65
D G Hoag by W Stameris	ws MIT	22 Dec 65

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: Sheet 1 of 1
LIS-300-10002-1

ICRA NO: 10-054
Sheet 2 of 2

ICD NO. LIS-300-10002

CCA NO. **DATE** 12-22-65

ICD TITLE
ABORT GUIDANCE SECTION ELECTRICAL INTERFACE WITH PRIMARY GUIDANCE AND NAVIGATION SUBSYSTEM

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Sheet 9 of 9

Change pin numbers on the connector and also on the connector identification chart as follows:

From	To
19	46
36	47
18	26
1	14
26	24
17	29
33	50
16	51

REASON: UPDATE AGS-PGNS WIRING INTERFACE

DRAWN BY: E. BAADE

ENG 37.3 1-64

REV

ICD NO. LIS-300-10002

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

INTERFACE CONTROL DOCUMENT

TDRR 21638 AUG 1[illegible]

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
HJB	GAEC	7/30/65
	GAEC	
WS	MIT	[illegible]

PREPARED BY: J. Pierini

CHECKED: F. Kratochvil

TITLE:
ABORT GUIDANCE SECTION ELECTRICAL INTERFACE WITH PRIMARY GUIDANCE AND NAVIGATION SUBSYSTEM

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO. 26512
SHEET 1 OF 9
ICD NO. LIS-300-10002
REV

INTERFACE CONTROL DOCUMENT

ENG 37.1 1-64

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
					GAEC		

KEY: Responsibility is identified herein as follows:

① Grumman Aircraft Engineering Corporation
Bethpage, L.I., New York

② Massachusetts Institute of Technology
Cambridge, Massachusetts

③ National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

④ Design Data to be supplied by:

SCOPE

The Electrical Interface between the Abort Guidance Section (AGS) of the Stabilization and Control Subsystem (SCS) and the CDU Assembly of the Primary Guidance and Navigation Subsystem (PGNS) is defined for the PGNS operating in any vehicle control mode. Signals are measured at the PGNS electrical interface connections. The functional interface requirements between AGS and PGNS are defined in LIS-540-10001.*

1. Definition of Voltages (Refer to Figure 1 for Pulse Waveform Definitions)

1.1 A continuous pulse train signal emanating from the CDU indicating that the CDU is being reset to zero.

1.1.1	Wave Shape:	pulse train
1.1.2	Frequency:	51.2 K pps ±10%
1.1.3	Pulse Amplitude (1 state):	7 volts ±3 volts
1.1.4	Pulse Amplitude (0 state):	-4 volts min to +0.4 volts max.
1.1.5	Pulse Rise and Decay Time:	0.5 microseconds max. (10%-90%)
1.1.6	Pulse Width:	3.0 ± 1 microseconds (50%-50%)
1.1.7	Load Impedance:	500 ohms ± 10% ohms (resistive)
1.1.8	Source Impedance:	Less than 100 ohms during the 1 state
1.1.9	Droop	20% of maximum positive amplitude
1.1.10	Timing Considerations	The CDU ZERO signal shall have a minimum duration of 300 milliseconds

1.2 Incremental Total Attitude Signals ± Δ Aig. ± Δ Amg. ± Δ Aog)

The incremental total attitude signals are defined by:

$$A_{ig} = \sum_{t=0}^{t} (+\Delta A_{ig}) - \sum_{t=0}^{t} (-\Delta A_{ig})$$

where Aig = PGNS total inner gimbal angle.

$+\Delta A_{ig}$ = positive incremental changes of PGNS inner gimbal angle.

$-\Delta A_{ig}$ = negative incremental changes of PGNS inner gimbal angle.

$t = 0$, is defined by the presence of the CDU ZERO signal.

The same definition applies to $\pm\Delta$ Amg and $\pm\Delta$ Aog where Amg is the PGNS total middle gimbal angle and Aog is the PGNS total outer gimbal angle. The incremental changes ($-\Delta$ Aig, $+\Delta$ Aig, $+\Delta$ Amg, $-\Delta$ Amg, $+\Delta$ Aog and $-\Delta$ Aog) are transmitted to the AGS in the form of incremental pulses on separate plus and minus signal lines as shown in Figure 3.

1.2.1	Waveshape	pulse train
1.2.2	Frequency	6.4 Kpps max for each signal

*This includes the functional interface requirements for AGS initialization via the LGC digital downlink. The electrical characteristics of this interface are described in LIS-370-10004.

TDRR 35886 MAR 21 1968

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	
W Stamens	MIT	13 Oct 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100
Exhibit E
Para. 5.6.2
Line Item 13
Primary No. 697
Type II

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512	IRN NO: LIS-300-10002-2 Sheet 1 of 1
	ICRA NO: 10-079 Page 3 of 19
ICD NO.	LIS-300-10002
CCA NO.	DATE 1/13/66
ICD TITLE	Abort guidance section electrical interface with primary guidance and navigation subsystem

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Ref. Sheet 1: In EFFECTIVITY zone, add the following;

—	ESI, LTA-1, LTA-1R, LTA-8, LEM-1 thru 15
REV	Model number

REASON: Add vehicle effectivity

DRAWN BY:

ENG 37.3 1-64

REF: CCA 497

CDRR 33838 MAY 22

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E. Stern	GAEC	1/30/6
WStameris	MIT/IL	13 Mar 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E ~~Primary No.~~ 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: SH 1 of 2
LIS 300-10002-3

ICRA NO: 10-203
Pg 2 of 18

ICD NO. LIS 300-10002

CCA NO. DATE 3/13/67

ICD TITLE Abort Guidance Section Electrical Interface with Primary Guidance and Navigation Subsystem

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Add Figure 3B (sheet 2 of this IRN) following present Figure 3 of the ICD.

Re-identify Figure 3 Interface Schematic as Figure 3A Interface Schematic (for LM-1 effectivity, see Figure 3B).

REASON: Deletion of Abort Guidance System from LM-1.

DRAWN BY: R. Kerr

1.2.3 Pulse Amplitude (1 state): 7 volts ± 3 volts
1.2.4 Pulse Amplitude (0 state): -4.0 volts min. to + 0.4 volts max.
1.2.5 Pulse Rise and Decay Time: 0.5 microseconds max. (10%-90%)
1.2.6 Pulse Width: 3.0 ± 1 microseconds (50%-50%)
1.2.7 Load Impedance: 500 ohms ± 10% ohms (resistive)
1.2.8 Source Impedance: Less than 100 ohms during the 1 state
1.2.9 Droop 20% of the maximum positive amplitude
1.2.10 Pulse Weight: $360/2^{15}$ degrees/pulse
1.2.11 Signal Phase: With the LEM vehicle axes and the PGNS Gimbal Axes either coincident or parallel (See Figure 2) the signal phasing of the Incremental Total Attitude Signal shall be as follows:

For positive LEM vehicle rotation about the X axis the Incremental Total Attitude Signal shall be a pulse train on the $+\Delta A_{og}$ line.

For negative LEM vehicle rotation about the X axis the Incremental Total Attitude Signal shall be a pulse train on the $-\Delta A_{og}$ line.

The same definition applies for vehicle rotation about the Y and Z LEM vehicle axis which results in pulse trains along the $\pm\Delta A_{ig}$ and $\pm\Delta A_{mg}$ lines respectively.

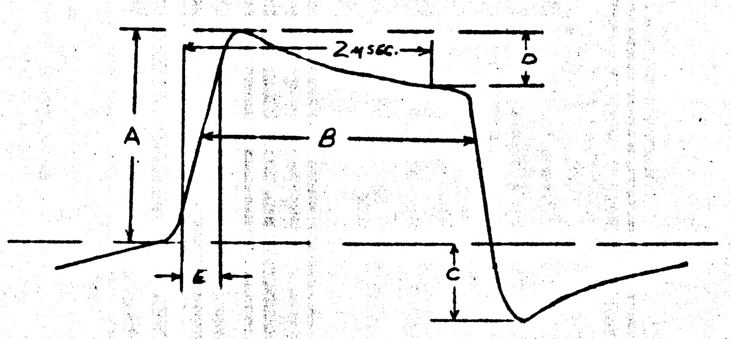
A positive LEM vehicle rotation is defined as a clockwise rotation of the LEM vehicle about an axis viewed from the inside of the LEM vehicle out along the positive direction of the axis (See Figure 2).

When the vectors defining the LEM vehicle axes and the PGNS Gimbal Axes are coincident this shall be defined as the PGNS gimbal zero position. A_{ig}, A_{mg}, and A_{og} shall be measured from the PGNS gimbal zero position.

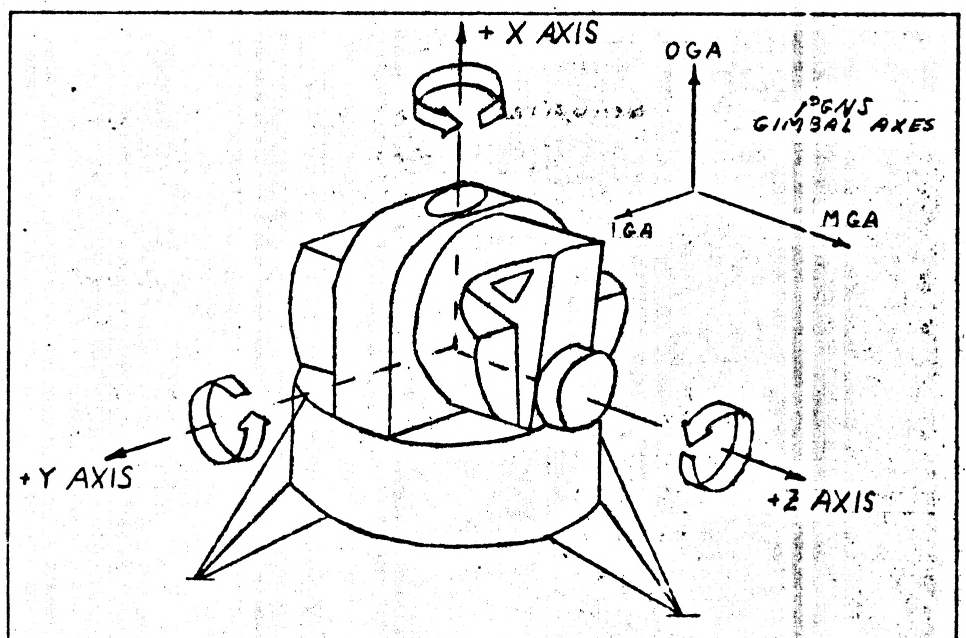
1.2.11 Timing Considerations Transmission of incremental pulses will be initiated no sooner than 585 microseconds after transmission of the last CDU ZERO pulse. All three CDU's A_{ig}, A_{mg}, and A_{og} may send at the maximum rate simultaneously.

FIGURE 1

PULSE WAVEFORM DEFINITIONS



A - AMPLITUDE, MEASURED TO PULSE MAXIMUM LEVEL
B - PULSE WIDTH, MEASURED AT A/2 LEVEL
C - BACKSWING, MEASURED TO MAXIMUM NEGATIVE LEVEL
D - DROOP, MEASURED FROM PULSE MAXIMUM POSITIVE LEVEL (A) TO THE LEVEL AT 2 μSEC.
E - RISE TIME, TIME REQUIRED FOR PULSE TO RISE FROM 10% TO 90% OF A



LEM VEHICLE AXES

NOTE:
X Axis: LEM Vehicle Yaw Axis
Y Axis: LEM Vehicle Pitch Axis
Z Axis: LEM Vehicle Roll Axis
OGA: PGNS Outer Gimbal Axis
IGA: PGNS Inner Gimbal Axis
MGA: PGNS Middle Gimbal Axis

Figure 1: Initial Orientation of LEM Vehicle Axes and PGNS Gimbal Axes

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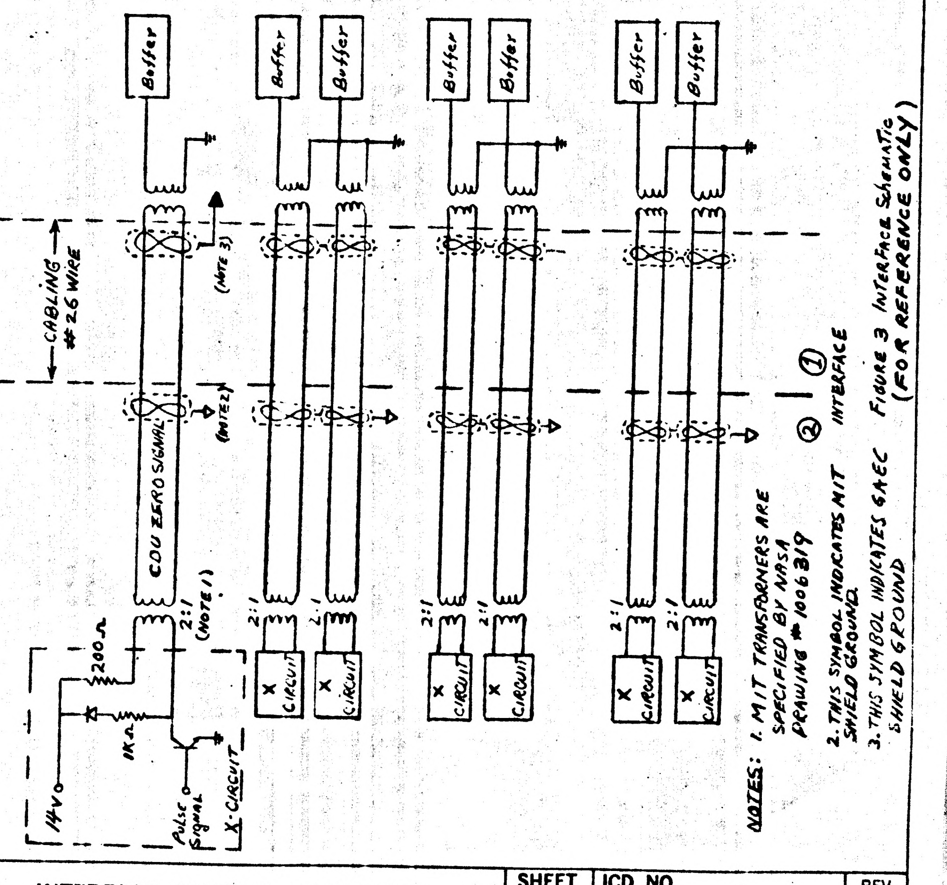


NOTES:
1. MIT TRANSFORMERS ARE SPECIFIED BY NASA DRAWING # 1006319
2. THIS SYMBOL INDICATES MIT SHIELD GROUND.
3. THIS SYMBOL INDICATES GAEC SHIELD GROUND

FIGURE 3 INTERFACE SCHEMATIC (FOR REFERENCE ONLY)

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

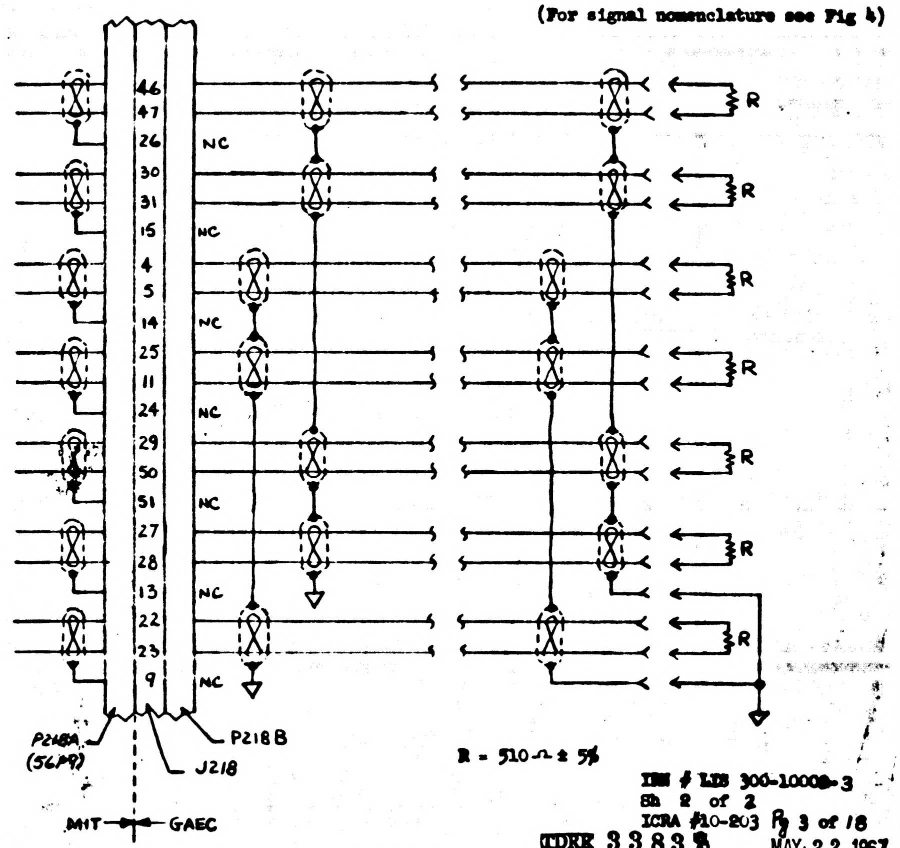
WS 3/13/67

FIGURE 3B - INTERFACE SCHEMATIC

EFFECTIVITY FOR THIS SHEET IS LM-1 ONLY

In place of the Abort Guidance System, appropriate load resistors will be implemented across the incremental total attitude and CDU zero signals as shown below. For AGS Initialization interface termination, see ICD # LIS 370-10004.

(For signal nomenclature see Fig 4)


46
47
26
30
31
15
4
5
14
25
11
24
29
50
51
27
28
13
22
23
9
NC
NC
NC
NC
NC
NC
NC
R
R
R
R
R
R
R
P218A
(56P9)
J218
P218B
MIT
GAEC

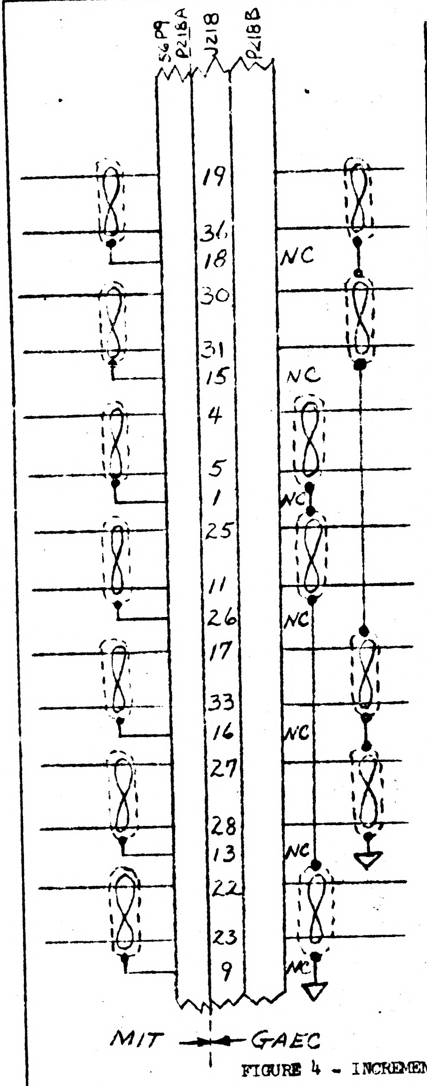
R = 510 Ω ± 5%

IDN # LIS 300-10008-3
Sh 2 of 2
ICRA #10-203 Pg 3 of 18

CDRR 33838 MAY 22 1967

INTERFACE CONTROL DOCUMENT	SHEET OF	ICD NO.	REV

ENG 37.2 1-64



Connector Identification PIN	Signal Identification
19	$+\Delta A_{ig}$: Positive Incremental Changes of Inner Gimbal Angle
36	Reference for $+\Delta A_{ig}$ Signal
30	$-\Delta A_{ig}$: Negative Incremental Changes of Inner Gimbal Angle
31	Reference for $-\Delta A_{ig}$ Signal
4	$+\Delta A_{mg}$: Positive Incremental Changes of Middle Gimbal Angle
5	Reference for $+\Delta A_{mg}$ Signal
25	$-\Delta A_{mg}$: Negative Incremental Changes of Middle Gimbal Angle
11	Reference for $-\Delta A_{mg}$ Signal
17	$+\Delta A_{og}$: Positive Incremental Changes of Outer Gimbal Angle
33	Reference for $+\Delta A_{og}$ Signal
27	$-\Delta A_{og}$: Negative Incremental Changes of Outer Gimbal Angle
28	Reference for $-\Delta A_{og}$ Signal
22	CDU ZERO: PGNS in CDU ZERO Mode
23	Reference for CDU ZERO Signal

NOTE: Connector types are defined in LID-39(-10001

FIGURE 4 - INCREMENTAL TOTAL ATTITUDE SIGNALS AND CDU ZERO SIGNAL

TDRR 35136 NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J D	GAEC	11/24
WStameris	MIT	16 Nov 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512	IRN NO: Sheet 1 of 2 LIS 350-10001-0 A-3 ICRA NO: 10-241 Sheet 3 of 6
ICD NO. LIS 350-10001A	
CCA NO.	DATE
ICD TITLE LM-PGNS ELECTRICAL INTERFACE FOR TOTAL ATTITUDE SIGNALS, ATTITUDE ERROR SIGNALS AND IMU CAGE SIGNAL	

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Delete Sheet 14 of the ICD and replace with new Sheet 14.
(Sheet 2 of this IRN)

On Sheet 12, Delete Pins 61 and 62 and all associated wiring and nomenclature.

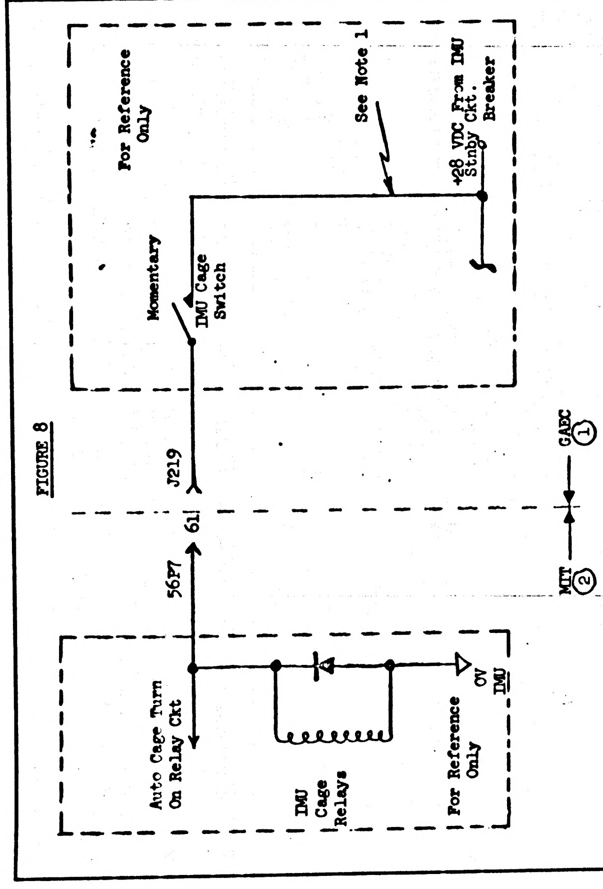
REASON: Modification of IMU Cage Circuit

DRAWN BY: R. Kerr

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

FIGURE 8


Auto Cage Turn On Relay Ckt
56P7
61
J219
Momentary
IMU Cage Switch
For Reference Only
IMU Cage Relays
See Note 1
For Reference Only
0V IMU
+28 VDC From IMU Stnby Ckt. Breaker
MIT ②
GAEC ①

IMU CAGE INTERFACE

NOTE 1. In LM-1, this wire is not connected, thereby permanently disabling the cage switch.

ICRA # 10-241
Sheet 4 of 6
IRN #LIS350-10001-0A-3
Sheet 2 of 2

approved WS 11/16/67

INTERFACE CONTROL DOCUMENT	SHEET OF	ICD NO.	REV
	14 of 14	LIS 350-10001	A

ENG 37.3 1-64

TDRR 35136 NOV 21 1967

TDRR 34687 SEP 25 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
JB N	GAEC	9/5/67
W Stamenis	MIT/IL	20 Sept 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No. 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS-370-10004B-10
Sheet 1 of 1
ICRA NO: 10-239
Page 2 of 2
ICD NO. LIS-370-10004B
CCA NO.
DATE
ICD TITLE
LGC-LM Electrical Interface

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Section II, Circuit 4

In paragraph at bottom of page:

Change Out of Detent indication from 3/4° ± 1/4° to 1 1/4° ± 3/4°
Change Quadrature from 10 mv. RMS max. to 20 mv. RMS max.
Change Scale Factor from 2.8 volts ± 0.14 volts RMS at 11° hand controller position to 2.8 volts $^{+0.14}_{-0}$ volts RMS at 10° nominal hand controller position (soft stop)
Change Source impedance from 2K at 85° to 21 ± 15% + j25.5 ± 10% ohms

Change: Linearity ± 10%, 3/4 < θ < 10°
Change: Quantization 42 states/10°
Change: Load impediance, non-linear 2-20K ohm effictivity 8 K ohm when not reading.

REASON:

DRAWN BY: J. Delessandro

BNG 37.3 1-64

TDRR 3 4 7 3 8 SEP 2 5 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J D H	GAEC	8/14/67
W Stameris	MIT	14 Aug 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: Sheet 1 of 2 LIS 370-10004 B-9
ICRA NO: 10-226 Sheet 2 of 3
ICD NO. LIS 370-10004 B
CCA NO. DATE
ICD TITLE LGC-LM Electrical Interface

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION: VEHICLE EFFECTIVITY - ESI, LTA-1, LTA-1R, LTA-8, LM 1-15

1. On Sheet 9 -
   Change electrical characteristics for signals D5, 6, 7 & 8 as follows:
   DC Voltage level for "0", change 18 ± 3 to 32.5 Max; 17 Min.
   Load Impedance (both "1" & "0"), change 7K to 11.5K
2. Replace Sheet 19 with Sheet 2 of this IRN
3. On Sheet 34 Note C. Delete the words "Data will be all zeros when LGC is in Standby" and add the same statement to the remarks column for signal M5 on Sheet 13.

REASON: Change DECA interface circuit for Gimbal Trim Commands

DRAWN BY: R. Kerr

GMG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

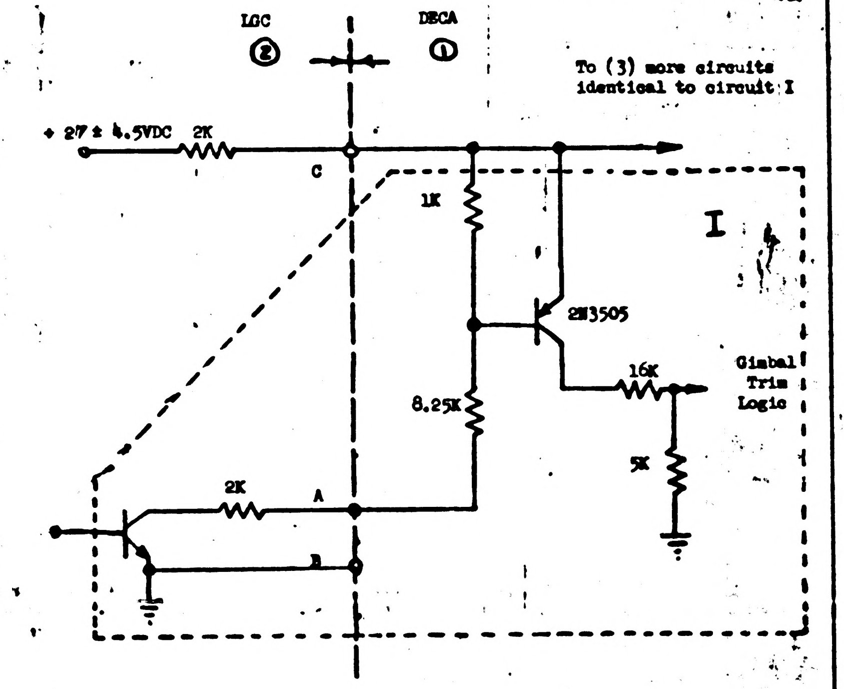
WS 14 Aug 67

ICRA 10-226
Sheet 3 of 3
IRN No. LIS 370-10004B-9
Sheet 2 of 2

SECTION II:

CIRCUIT 2 B: Gimbal Trim Commands

TDRR 3 4 7 8 8 SEP 2 5 1967



To (3) more circuits identical to circuit I

Signal Levels specified between points A and B at interface, with point B as the reference Level

Noise Limits:

("1") Maximum noise amplitude = +50V, if noise pulse does not exceed 0.5 msec width at max. rep rate of 50 pps.

("0") Maximum noise amplitude = -50V, if noise pulse does not exceed 1 msec width at max. rep rate of 50 pps.

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
	19 OF 46	LIS 370-10004	B

GMG 37.3 1-64

[illegible] TDRR 34687 SEP 25 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE	INTERFACE REVISION NOTICE	CODE IDENT NO.	IRN NO: Sheet 1 of 1 LIS 370-10004B-11
J B Harris	GAEC	9/21/67	INTERFACE CONTROL DOCUMENT	26512	ICRA NO: 10-230 Sheet 2 of 3
W. Stameris	MIT 20 Sep	1967		ICD NO.	LIS 370-10004B
				CCA NO.	DATE
			GRUMMAN AIRCRAFT ENGINEERING CORPORATION BETHPAGE, L. I., NEW YORK	ICD TITLE	LGC-LM ELECTRICAL INTERFACE

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

1. ON SHEET 15 ADD "SEE NOTE 1 BELOW" AFTER "STANDBY" (SIGNAL 0-7)
ADD: "NOTE 1: FOR LM-2 & SUBSEQ., THIS SIGNAL WILL
BE "STANDBY/PROCEED".

2. IN SECTION IV IDENTIFY NOMINCIATURE CHANGE AND EFFECTIVITY FOR SIGNALS ON
J221 PIN 28 AS IN ITEM ~~ABOVE~~. 1 Above

REASON: IMPLEMENTATION OF "AUTO PROCEED" FUNCTION

DRAWN BY: R. KERR

ENG 37 3 1 64

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	5/7/68
W.Q. Stameric	MIT	7 May 68

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primery No. 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: Sheet 1 Of 1
LIS-370-10003A-3

ICRA NO: 10-257
Sheet 2 Of 2

ICD NO. LIS-370-10003 Rev. A

CCA NO. **DATE**

ICD TITLE
LEM - PGNS Measurement
Interface Provisions

IDRR 36676 AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

In Table III, Change Z_L (Load Impedance) for the following measurements from 500K to 250K

NG 1021 V
NG 1031 V
NG 1071 V
NG 1501 V
NG 1511 V
NG 1521 V

REASON: Correct Load Impdance Value For RMS Noise Measurements

DRAWN BY: R. Kerr

ENG 37.3 1-66

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E. Stern	GAEC	10/25/65
D.G. Hoag	MIT/IL	26 Oct 65

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: L15-370-10003-1 SHEET 1 OF 1

ICRA NO: 10-038 PAGE 2 OF 3

ICD NO. L15-370-10003

CCA NO. DATE

ICD TITLE LEM-PGNS MEASUREMENT INTERFACE PROVISIONS

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DESCRIPTION:

NO CHANGE

TDRR 23655 NOV 2 1965

REASON: IRN NO. USED ON PRELIMINARY DOCUMENT

DRAWN BY: E. BAADE

ENG 37.3 1-64

REV

ICD NO. LIS 370-10003

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

INTERFACE CONTROL DOCUMENT

TDRR 21638 AUG 17 1965

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APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E. Stern	GAEC	7/28/65
[illegible] CAO	MIT	22 July 65

PREPARED BY: R. Kerr R Kerr
CHECKED: G. Henderson G Henderson 7/28/65

TITLE:

LEM-PGNS MEASUREMENT INTERFACE PROVISIONS

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	SHEET 1 OF 35	LIS 370-10003	

INTERFACE CONTROL DOCUMENT

ENG 37.1 1-64

REVISIONS

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					GAEC		

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

REV	ICD NO. LIS 370-10003

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APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E. Stern	GAEC	7/28/65
CAO	MIT	

PREPARED BY: R. Kerr R Kerr

CHECKED: G. Henderson G Henderson 7/28/65

TITLE:

LEM-PGNS MEASUREMENT INTERFACE PROVISIONS

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	1 OF 35	LIS 370-10003	

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3.4 LGC Serial Downlink Provisions
3.5 PCM/TEA Low Bit Rate Provisions

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Fig. 1A Typical PCM Single Diode Gate
Fig. 1B Typical PCM High Level Analog Gate
Fig. 2A MIT Output Circuit for PB Signals
Fig. 2B MIT Output Circuit for PU Signals
Fig. 2C MIT Output Circuit for PD Signals
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GLOSSARY OF TERMS

1	Grumman Aircraft Engineering Corp.
2	Massachusetts Institute of Technology Inst. Lab
3	National Aeronautics and Space Administration
4	Design Data to be Supplied By
ACD	AC to DC Converter
ANC	AC Noise Converter
Cal. Mod.	Calibration Module
CC	Isolated Contact Closure
CDU	Electronics Coupling Data Unit
C & W	Caution and Warning
DCA	DC Amplifier
DFI	Development Flight Instrumentation
DSKY	Display Keyboard
FTA	Flight Test Article
GAEC	Grumman Aircraft Engineering Corp.
GFE	Government Furnished Equipment
GLD or GL	Glitch Detector
G & N	Guidance and Navigation
GSE	Ground Support Equipment
ICD	Interface Control Document
ID	Measurement Identification Number
IES	Internal Environmental Simulator
IG	Inner Gimbal
IMU	Inertial Measuring Unit
IRIG	Inertial Rate Integrating Gyro
ISA	Isolation Attenuator
ISS	Inertial Sub System
LED	LEM Engineering Document
LEM	Lunar Excursion Module
LGC	LEM Guidance Computer

GLOSSARY OF TERMS (cont'd)

LID	LEM Interface Drawing
LIS	LEM Interface Specification
LMO	LEM Memorandum
LRE	Least Replaceable Equipment
LTA	LEM Test Article
MCR	Measurement Change Request
MG	Middle Gimbal
MIT	Massachusetts Institute of Technology, Inst. Lab
NASA	National Aeronautics and Space Administration
OG	Outer Gimbal
P	Per Cent
PAM/FM/FM	Pulse Amplitude Modulated/Frequency Modulated/Frequency Modulation
PB	Preconditioned Analog Derived from Bi-Polar Signal
PCM	Pulse Code Modulation
PD	Preconditioned Bi-Level Discrete
PGNS	Primary Guidance and Navigation System
PIPA	Pulse Integrating Pendulous Accelerometer
PSA	Power and Servo Assembly
PSD	Phase-Sensitive Demodulator
PU	Preconditioned Analog Derived from Unipolar Signal
RA	Raw Analog Voltage
RD	Raw Discrete Voltage
R & D	Research and Development
REC	PSD Reference Conditioner
REG	PSD Reference Generator
RR	Rendezvous Radar
SCA	Signal Conditioner Assembly
S/G	Signal Generator
SLA	Service LEM Adaptor
TEA	Timing Electronics Assembly
T/M	Telemetered or Telemetry
VCO	Voltage Controlled Oscillator
Z_{in}	Input Impedance

GLOSSARY OF TERMS (cont'd)

Z_L	Load Impedance
Z_S	Source Impedance

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G & N	Guidance and Navigation
GSE	Ground Support Equipment
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IRIG	Inertial Rate Integrating Gyro
ISA	Isolation Attenuator
ISS	Inertial Sub System
LED	LEM Engineering Document
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LGC	LEM Guidance Computer

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LID	LEM Interface Drawing
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RA	Raw Analog Voltage
RD	Raw Discrete Voltage
R & D	Research and Development
REC	PSD Reference Conditioner
RFG	PSD Reference Generator
RR	Rendezvous Radar
SCA	Signal Conditioner Assembly
S/G	Signal Generator
SLA	Service LEM Adaptor
TEA	Timing Electronics Assembly
T/M	Telemetered or Telemetry
VCO	Voltage Controlled Oscillator
Z_{in}	Input Impedance

GLOSSARY OF TERMS (cont'd)

Z_L	Load Impedance
Z_S	Source Impedance

1.0 Scope

This ICD establishes the provisions for LEM G & N, GFE measurements in the following four categories:

a) Telemetry Measurements
b) GSE Stimuli
c) GSE Measurements
d) Caution and Warning measurements

The measurement points to be provided by MIT for the purpose of fault detection and isolation during prelaunch checkout may require additions to or revisions of the lists of measurement points included in this ICD. The following guidelines must, however, be observed:

a) Sufficient measurement points must be provided to allow fault detection to an adequate level of confidence.

b) As a minimum, sufficient measurement points must be provided such that, in conjunction with other LEM measurements, it is possible to isolate faults to the MIT G & N equipment.

c) Sufficient measurements must be provided to minimize the removal of equipment for the purpose of fault isolation to the extent necessary to allow maintenance times and procedures consistent with vehicle preparation and launch requirements.

1.1 Vehicle Effectivities

Vehicle effectivities are not included in this ICD. The final determination of specific measurements to be implemented for a given vehicle is subject to NASA approval of the following Measurements Lists:

Vehicle	Document Number
IES (Internal Environmental Simul.)	LED-360-157
FTA-1	LED-360-21
LTA-1	LED-360-201
LTA-2	LED-360-202

1.1 Vehicle Effectivities (cont'd)

Vehicle	Document Number
LTA-3	LED-360-203
LTA-4	LED-360-204
LTA-5	LED-360-205
LTA-8	LED-360-208
LTA-10	LED-360-210
LEM 1,2,3	LED-360-22
LEM 10	LED-360-7

1.2 Measurement List Change Procedure

The established change procedure for the above Measurement Lists utilizes the Measurement Change Request (MCR) standard form as denoted in documents LMO-250-99 dated 7 May, 1965 and LM)-260-67 dated 20 May, 1965.

1.3 Interface Connector and Pin Assignments

The controlling document for connector and pin assignments will be the Electrical Wiring ICD #LID-390-10001.

In general, the following signal/connector relationships will be used:

J217 will be used for all operational Instrumentation interfaces and all R & D telemetry requiring real time display.

J220 will be used for all R & D telemetry not requiring real time display.

J232 will be used for all GSE measurements and stimuli with the exception of "IMU Temp. Out of Limits" which will be routed to the LEM/SLA umbilical through J217.

2.0 Crew Displays

Crew Displays with the exception of DSKY Displays are measurements which are displayed directly on the LEM vehicle. These measurements consist of the following:

a) Caution and Warning
b) Altitude and Altitude Rate

c) Analog, Forward and Lateral Velocity
d) Total Attitude
e) Attitude Error

2.1 Analog and Digital Displays

The PGNS electrical interface with these Displays is covered in separate ICD's. They are listed below for reference:

Meas. ID	Description	Controlling ICD
GG0117	Position, Altitude	LIS-370-10004
GG0118	Velocity, Altitude Rate	LIS-370-10004
GG0119	Velocity, Forward	LIS-350-10002
GG0120	Velocity, Lateral	LIS-350-10002
GG2122	IG 1x Resolver, Sin	LIS-350-10001
GG2123	IG 1x Resolver, Cos	
GG2152	MG 1x Resolver, Sin	
GG2153	MG 1x Resolver, Cos	
GG2182	OG 1x Resolver, Sin	
GG2183	OG 1x Resolver, Cos	
GG2247	Pitch Attitude Error (PGNS)	
GG2247	Roll Attitude Error (PGNS)	
GG2277	Yaw Attitude Error (PGNS)	LIS-350-10001

The functional requirements for the above Display interfaces are defined in ICD #LIS-540-10001.

2.2 Caution and Warning

The PGNS Caution and Warning interface consists of the following signals:

Meas. ID	Description
GG9001	LGC (Warning)
GG9002	ISS (Warning)
GG9003	PGNS (Caution)

2.21 Functional Requirements (C & W)

The three C & W signals are issued in the form of isolated DSKY contact closures (see ICD #LIS-370-10004) and represent an individual, or combination of abnormal* or failure conditions common to a major section of the PGNS. The derivation of these three signals is shown in figure 3.

The PGNS shall be capable of issuing each of the C & W contact closures in all operating modes where the individual functions monitored, exist normally in that mode. The PGNS shall, conversely, internally inhibit the individual failure detection of a function that is normally absent in a particular operating mode; i.e. - The Gyro Wheel Supply in "IMU STANDBY" mode.

In the case of the two "WARNING" contact closures (GG9001,9002), the remedial or abortive action associated with each is the same as that which would be required for each of the individual signals that are combined to make it up.

The remedial action associated with the "CAUTION" contact closure (GG9003) varies with the individual signal that triggers it. The Astronaut will be notified via DSKY Caution lights as to which individual abnormal condition exists.

The issuance of any one of the C & W contact closures shall activate the Caution and Warning Assembly unless an external inhibit signal is present. External INHIBITS, which indicate that the proper action has been taken, shall be determined by GAEC.

* Excluding transients that would not affect PGNS operation.

2.22 C & W Mechanization

The contact closure associated with each PGNS Caution or Warning output signal is monitored by a dual output event buffer providing inputs to both the PCM telemetry equipment and the C & W equipment.

No closures of 100 microseconds or longer shall be issued by the PGNS unless they constitute a failure or abnormal condition consistent with section 2.21 of this ICD. Conversely, the closure shall be maintained if, in fact, the failure or abnormal condition exists. Opening of the contacts after clearance of the failure within PGNS, shall cause the caution or warning lights to be extinguished.

When Guidance Control is switched to the Abort Guidance System, an inhibit

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This ICD establishes the provisions for LEM G & N, GFE measurements in the following four categories:

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b) GSE Stimuli
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The issuance of any one of the C & W contact closures shall activate the Caution and Warning Assembly unless an external inhibit signal is present. External INHIBITS, which indicate that the proper action has been taken, shall be determined by GAEC.

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2.22 C & W Mechanization

The contact closure associated with each PGNS Caution or Warning output signal is monitored by a dual output event buffer providing inputs to both the PCM telemetry equipment and the C & W equipment.

No closures of 100 microseconds or longer shall be issued by the PGNS unless they constitute a failure or abnormal condition consistent with section 2.21 of this ICD. Conversely, the closure shall be maintained if, in fact, the failure or abnormal condition exists. Opening of the contacts after clearance of the failure within PGNS, shall cause the caution or warning lights to be extinguished.

When Guidance Control is switched to the Abort Guidance System, an inhibit for all three C & W lights is provided for in the GAEC equipment.

3.0 Telemetry Measurement Provisions

The specific LEM Vehicle Measurement Lists, identified in section 1.1, will control which measurements are monitored by each telemetry system as well as the associated bandwidth, accuracy and range of the measurement. This effectivity is therefore not defined herein.

It is intended that this section will supplement the appropriate measurement list by specifying the general class of each measurement, the required format and interface electrical characteristics and the grounding or signal return conventions.

The telemetry signals implemented for a given vehicle shall be active in all PGNS modes of operation where the function that is monitored is active within the PGNS. When a telemetry signal becomes inactive or does not apply due to PGNS moding, the voltage and source impedance at the interface shall remain within the limits specified herein.

3.1 Table I Description

Table I is a gross listing of all contemplated in-flight telemetry measurements to be monitored by either the Operational PCM/TEA System (PCM) or the Development Flight Instrumentation (DFI) PAM/FM/FM System.

The signal class and associated MIT output circuit are listed in this table. The GAEC PCM input circuits are shown for reference in figures 1A and 1B. The MIT output circuits are shown for reference in figures 2A and 2B, and 2C.

3.11 Measurement Identification (ID) Number

Each measurement has a seven character number assigned to it. Characters 1, 2 & 7 are letters representing the Module Code, Functional Subsystem, and Measurement Classification Code respectively. Characters 3 through 6 are numbers representing the Identification Number.

As used in this ICD, the Module Code will be either a "G" denoting a LEM derived measurement or a "H" denoting a GSE measurement derived from a LEM measurement.

The Functional Subsystem Code "G" indicates that the measurement is related to the Navigation and Guidance Subsystem. The Measurement Classification Code letters used in this ICD are as follows:

B - phase
C - current
T - temperature
V - velocity
X - discrete

3.12 Measurement Nomenclature

A brief, definitive title has been given to each measurand and stimuli in this ICD. However, the individual Measurement Lists defined in section 1.1 will control these titles.

3.13 MIT Output Circuit

Figures 2A, 2B, 2C represent typical MIT out put circuits for PB, PU and PD signals respectively. Out put filter values vary with signal bandwidth/sampling rate and are therefore not included.

3.14 Signal Class

There are three classes of signals used in Table I. They are:

a) PB - Indicates preconditioned analog derived from bipolar signal.
b) PU - Indicates preconditioned analog derived from unipolar signal.
c) PD - Indicates preconditioned bi-level discrete.

The PD class signal applies to PCM monitored discretes only. Discrete or event signals monitored by the DFI System are processed as analog data and fall into the PU signal class.

For both classes of analog signals the voltage range at the interface shall be 0 to +5 VDC. The PB class denotes which signals are referenced to the appropriate 2.5 VDC bias supply.

The "OFF" and "ON" levels for discrete signals is nominally 0 to +5 VDC respectively.

The limits of the voltage at the interface is as follows:

"ON" shall be within +3.5 VDC to +10.0 VDC
"OFF" shall be within -0.5 VDC to +1.0 VDC

The "ON" and "OFF" voltage levels (within the 0 to +5 VDC range) for the DFI monitored discretes shall be:

OFF - 0 to 1 VDC
ON - +3.5 to 5.0 VDC

3.15 Measurement Scale

Range - The requested recoverable range expressed in low, nominal and high values.

for all three C & W lights is provided for in the GAEC equipment.

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The telemetry signals implemented for a given vehicle shall be active in all PGNS modes of operation where the function that is monitored is active within the PGNS. When a telemetry signal becomes inactive or does not apply due to PGNS moding, the voltage and source impedance at the interface shall remain within the limits specified herein.

3.1 Table I Description

Table I is a gross listing of all contemplated in-flight telemetry measurements to be monitored by either the Operational PCM/TEA System (PCM) or the Development Flight Instrumentation (DFI) PAM/FM/FM System.

The signal class and associated MIT output circuit are listed in this table. The GAEC PCM input circuits are shown for reference in figures 1A and 1B. The MIT output circuits are shown for reference in figures 2A and 2B, and 2C.

3.11 Measurement Identification (ID) Number

Each measurement has a seven character number assigned to it. Characters 1, 2 & 7 are letters representing the Module Code, Functional Subsystem, and Measurement Classification Code respectively. Characters 3 through 6 are numbers representing the Identification Number.

As used in this ICD, the Module Code will be either a "G" denoting a LEM derived measurement or a "Y" denoting a GSE measurement derived from a LEM measurement.

The Functional Subsystem Code "G" indicates that the measurement is related to the Navigation and Guidance Subsystem. The Measurement Classification Code letters used in this ICD are as follows:

B - phase
C - current
T - temperature
V - velocity
X - discrete

3.12 Measurement Nomenclature

A brief, definitive title has been given to each measurand and stimuli in this ICD. However, the individual Measurement Lists defined in section 1.1 will control these titles.

3.13 MIT Output Circuit

Figures 2A, 2B, 2C represent typical MIT out put circuits for PB, PU and PD signals respectively. Out put filter values vary with signal bandwidth/sampling rate and are therefore not included.

3.14 Signal Class

There are three classes of signals used in Table I. They are:

a) PB - Indicates preconditioned analog derived from bipolar signal.
b) PU - Indicates preconditioned analog derived from unipolar signal.
c) PD - Indicates preconditioned bi-level discrete.

The PD class signal applies to PCM monitored discretes only. Discrete or event signals monitored by the DFI System are processed as analog data and fall into the PU signal class.

For both classes of analog signals the voltage range at the interface shall be 0 to +5 VDC. The PB class denotes which signals are referenced to the appropriate 2.5 VDC bias supply.

The "OFF" and "ON" levels for discrete signals is nominally 0 to +5 VDC respectively.

The limits of the voltage at the interface is as follows:

"ON" shall be within +3.5 VDC to +10.0 VDC
"OFF" shall be within -0.5 VDC to +1.0 VDC

The "ON" and "OFF" voltage levels (within the 0 to +5 VDC range) for the DFI monitored discretes shall be:

OFF - 0 to 1 VDC
ON - +3.5 to 5.0 VDC

3.15 Measurement Scale

Range - The requested recoverable range expressed in low, nominal and high values.

Units - Engineering units of the measurand or stimuli.

3.2 Grounding and Signal Returns for T/M Meas.

Common returns for each signal grouping, defined in sections 3.21, 3.22 and 3.23, shall be isolated from each other and from ground on the MIT side of the interface. The single point ground for each group's common return shall be provided by GAEC.

Separate 2.5 VDC bias supplies shall be provided by MIT to convert PB class signals and maintain common return isolation between the PCM/TEA System and the DFI System. The bias level shall be included as one of the PU class measurements monitored by each System.

3.21 PCM Discrete Returns

Each group of eight or less PD class signals form a PCM word and are sampled at the same rate. Each grouping shall have an isolated common return provided by MIT.

3.22 PCM Analog Returns

Each group of six or less PU/PB class signals, monitored by the PCM/TEA System, shall be provided with a common return.

These separate common returns may have a common origin on the MIT side of the interface, but they shall be isolated from other common origins and returns.

3.23 DFI Returns

Each group of six or less PU/PB class signals, monitored by the DFI System, shall be provided with a common return. These separate common returns may have a common origin on the MIT side of the interface, but they shall be isolated from other common origins and returns.

3.3 Source and Load Impedance For Telemetry Measurements

The MIT source impedance for PU, PB and PD class signals shall be 5 K ohms or

less. This applies both "ON" and "OFF" levels of PD class.

The GAEC load impedance shall be as follows:

PD Class - non-loading active diode gate. (see figure 1A)
PU/PB class (monitored by PCM) - 1 Megohm or greater
PU/PB class (monitored by DFI VCO[1]) - 750 K ohms
PU/PB class (monitored by DFI PAM - 1.5 Megohm or greater

NOTE: 1. DFI VCO monitor is denoted by the absence of sampling rate on measurement lists.

3.4 LGC Serial Downlink Provisions

The LGC Serial Digital Downlink is provided in the normal (51.2 kilobit per second) PCM/TEA mode only.

This interface consists of a 40 bit downlink word that is sampled by the PCM/TEA 50 times per second. This 40 bit downlink word is made up of: a single word order code bit, two computer words of 16 bits each, and seven unused bits.

The general nature of the 16 bit computer word is either: 16 individual event or status discrete bits, or 14 data bits with a sign and parity bit.

Data that requires more than 2^{14} resolution will be contained in two 16 bit computer words (i.e. double precision words); one containing the most significant data bits (MSB) and the other containing the least significant data bits (LSB).

A 40 bit downlink word may contain either two different 16 bit computer words or a single word repeated redundantly.

The data to be contained in this LGC downlink, as well as data repetition and mission phase effectivity, shall be controlled by the vehicle measurement list.

The electrical characteristics and timing provisions of the LGC - PCM/TEA downlink interface are controlled by ICD LIS-37 -10004.

3.5 PCM/TEA Low Bit Rate Provisions

The PCM/TEA provides a reduced format (low bit rate) mode of operation,

during which critical data is encoded at 1.6 kilobits per second instead of the normal 51.2 kilobits per second. Low bit rate mode operating intervals are denoted in AMPTF Design Reference Mission LED-540-12.

The PCM/TEA low bit rate provisions for PGNS measurements are as follows:

No LGC serial digital data shall be encoded or timing signals provided by PCM/TEA.

Only steady state (one sample per second) analog and discrete measurements shall be retained and encoded by PCM/TEA.

Low bit rate effectivity shall be controlled by the vehicle measurement list and is denoted in the "T/M Hi-lo" column.

4.0 GSE Stimuli Provisions

The intent of this section is to establish the electrical characteristics for GAEC supplied stimuli to PGNS for the purpose of prelaunch checkout.

4.1 Table II Description

Table II is a GSE Stimuli Provisions Selection List which contains all of the presently conceived stimuli requested by MIT.

4.11 ID Number

See section 3.11

4.12 Measurement Nomenclature

See section 3.12

4.13 Destination LRE

Column titled "LRE USED IN" defines the MIT package in which the stimuli will ultimately be used in:

i.e. - the three step inputs are inputs to the Servo Amplifiers in the PSA.

4.14 Signal Class

The "CLASS" column identifies the output or source circuit which supplies the stimuli to the interface. The CC class identifies the source circuit as an isolated contact closure.

4.15 Stimuli Characteristics

Range	-	The requested range expressed in low nominal and high values.
Z_s	-	The source impedance looking into the GAEC side of the interface at the PSA ADAPTOR.
Z_L	-	The load impendance looking into the MIT side of the interface at the PSA ADAPTOR.

5. GSE Measurements Provisions

The purpose of this section is to define the electrical characterisitics of the GSE measurements, required for prelaunch checkout, on both sides of the MIT/GAEC interface.

5.1 Table III Description

Table III is the GSE Measurements Provisions Selection List which is a gross listing of all contemplated GSE measurements in accordance with the ground rules set forth in Section 1.0 of this ICD.

5.11 ID Number

See section 3.11.

5.12 Measurement Nomenclature

See section 3.12

5.13 Signal Class

The signal class identifies the type of signal supplied to GSE by MIT. In

Units - Engineering units of the measurand or stimuli.

3.2 Grounding and Signal Returns for T/M Meas.

Common returns for each signal grouping, defined in sections 3.21, 3.22 and 3.23, shall be isolated from each other and from ground on the MIT side of the interface. The single point ground for each group's common return shall be provided by GAEC.

Separate 2.5 VDC bias supplies shall be provided by MIT to convert PB class signals and maintain common return isolation between the PCM/TEA System and the DFI System. The bias level shall be included as one of the PU class measurements monitored by each System.

3.21 PCM Discrete Returns

Each group of eight or less PD class signals form a PCM word and are sampled at the same rate. Each grouping shall have an isolated common return provided by MIT.

3.22 PCM Analog Returns

Each group of six or less PU/PB class signals, monitored by the PCM/TEA System, shall be provided with a common return.

These separate common returns may have a common origin on the MIT side of the interface, but they shall be isolated from other common origins and returns.

3.23 DFI Returns

Each group of six or less PU/PB class signals, monitored by the DFI System, shall be provided with a common return. These separate common returns may have a common origin on the MIT side of the interface, but they shall be isolated from other common origins and returns.

3.3 Source and Load Impedance For Telemetry Measurements

The MIT source impedance for PU, PB and PD class signals shall be 5 K ohms or

less. This applies both "ON" and "OFF" levels of PD class.

The GAEC load impedance shall be as follows:

PD Class - non-loading active diode gate. (see figure 1A)
PU/PB class (monitored by PCM) - 1 Megohm or greater
PU/PB class (monitored by DFI VCO^1) - 750 K ohms
PU/PB class (monitored by DFI PAM - 1.5 Megohm or greater

NOTE: 1. DFI VCO monitor is denoted by the absence of sampling rate on measurement lists.

3.4 LGC Serial Downlink Provisions

The LGC Serial Digital Downlink is provided in the normal (51.2 kilobit per second) PCM/TEA mode only.

This interface consists of a 40 bit downlink word that is sampled by the PCM/TEA 50 times per second. This 40 bit downlink word is made up of: a single word order code bit, two computer words of 16 bits each, and seven unused bits.

The general nature of the 16 bit computer word is either: 16 individual event or status discrete bits, or 14 data bits with a sign and parity bit.

Data that requires more than 2^{14} resolution will be contained in two 16 bit computer words (i.e. double precision words); one containing the most significant data bits (MSB) and the other containing the least significant data bits (LSB).

A 40 bit downlink word may contain either two different 16 bit computer words or a single word repeated redundantly.

The data to be contained in this LGC downlink, as well as data repetition and mission phase effectivity, shall be controlled by the vehicle measurement list.

The electrical characteristics and timing provisions of the LGC - PCM/TEA downlink interface are controlled by ICD LIS-37 -10004.

3.5 PCM/TEA Low Bit Rate Provisions

The PCM/TEA provides a reduced format (low bit rate) mode of operation,

during which critical data is encoded at 1.6 kilobits per second instead of the normal 51.2 kilobits per second. Low bit rate mode operating intervals are denoted in AMPTF Design Reference Mission LED-540-12.

The PCM/TEA low bit rate provisions for PGNS measurements are as follows:

No LGC serial digital data shall be encoded or timing signals provided by PCM/TEA.

Only steady state (one sample per second) analog and discrete measurements shall be retained and encoded by PCM/TEA.

Low bit rate effectivity shall be controlled by the vehicle measurement list and is denoted in the "T/M Hi-lo" column.

4.0 GSE Stimuli Provisions

The intent of this section is to establish the electrical characteristics for GAEC supplied stimuli to PGNS for the purpose of prelaunch checkout.

4.1 Table II Description

Table II is a GSE Stimuli Provisions Selection List which contains all of the presently conceived stimuli requested by MIT.

4.11 ID Number

See section 3.11

4.12 Measurement Nomenclature

See section 3.12

4.13 Destination LRE

Column titled "LRE USED IN" defines the MIT package in which the stimuli will ultimately be used in:

i.e. - the three step inputs are inputs to the Servo Amplifiers in the PSA.

4.14 Signal Class

The "CLASS" column identifies the output or source circuit which supplies the stimuli to the interface. The CC class identifies the source circuit as an isolated contact closure.

4.15 Stimuli Characteristics

Range - The requested range expressed in low nominal and high values.
Zs - The source impedance looking into the GAEC side of the interface at the PSA ADAPTOR.
Z_L - The load impendance looking into the MIT side of the interface at the PSA ADAPTOR.

5. GSE Measurements Provisions

The purpose of this section is to define the electrical characterisitics of the GSE measurements, required for prelaunch checkout, on both sides of the MIT/GAEC interface.

5.1 Table III Description

Table III is the GSE Measurements Provisions Selection List which is a gross listing of all contemplated GSE measurements in accordance with the ground rules set forth in Section 1.0 of this ICD.

5.11 ID Number

See section 3.11.

5.12 Measurement Nomenclature

See section 3.12

5.13 Signal Class

The signal class identifies the type of signal supplied to GSE by MIT. In addition to the PB, PU, PD and CC classes defined in sections 3.14 and 4.14, the following signal classes are also defined:

RA - Raw Analog Voltage
RD - Raw Discrete Voltage

5.14 Measurement Scale

Range - The range, in engineering units, of the measurand, represented by voltage range defined in section 5.15 and expressed in low, nominal and high values.

Units - Engineering units of the measurand.

5.15 Electrical Characteristics

Voltage Range - The voltage range at the interface expressed in low, nominal and high values.

Zs - The source impedance looking into the MIT side of the interface at the PSA ADAPTOR.

Z_L - The load impedance looking into the GAEC side of the interface at the PSA ADAPTOR.

The source and load impedances for the "IMU TEMP. OUT OF LIMITS" discrete are defined as follows:

Zs - The source impedance looking into the MIT side of the interface at J217.

Z_L - The load impedance looking into the GAEC side of the interface at J217.

5.16 GSE Signal Conditioning

This section defines the signal conditioners on the GAEC side of the interface by type, subtype and full scale output as follows:

ACD - AC to DC Converter converts sine and square save input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the ACD is greater than 500 K ohms.

The output frequency response for all subtypes of the ACD is constant within 1 per cent for amplitude modulation rates of 0 to 60 CPS.

The ACD Subtypes and their input signal range are:

Class ACD 40 - 0 to 100 mv rms through 6 v rms from 400 to 3200 CPS
Class ACD 41 - 0 to 5 v rms through 150 v rms from 400 to 3200 CPS
Class ACD 42 - 105 v rms to 130 v rms at 400 CPS only (expanded scale)
Class ACD 43 - 0 to 100 mv rms through 5 v rms at 25.6 KCPS

The reference document for the ACD is Procurement Spec. MC 901-0278B

5.16 GSE Signal Conditioning (cont'd)

DCA - DC amplifier which converts low-level, DC input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the DCA is greater than 500 K ohms with the exception of class 05 which has an input impedance greater than 1 Megohm from 0 to 200 CPS.

The output frequency response for all subtypes of the DCA is constant within 1 per cent for input signal frequencies from 0 to 50 CPS for class 01 and 02 and from 0 to 100 CPS for class 05.

The DCA Subtypes and their input signal range are:

Class DCA 01 - 0 to +20 mv DC through 0 to +250 mv DC
Class DCA 02 - 0 to +250 mv DC through 0 to +5 VDC
Class DCA 05 - 0 to +1 VDC through 0 to +5 VDC

The reference document for the DCA is Procurement Spec. MC 901-0261A

ISA - The isolation attenuator attenuates DC input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the ISA is greater than 500 Kohms
The output frequency response for all subtypes of the ISA is constant

within 1 per cent for input signals from 0 to 50 CPS.

The ISA Subtypes and their input signal range are:

Class ISA 20 - 0 to +5 VDC through 0 to +50 VDC
Class ISA 22 - 0 to -5 VDC through 0 to -50 VDC

The reference document for the ISA is Procurement Spec. MC 901-02[illegible]0A.

PSD - The phase-sensitive demodulator produces a 0 to +5 VDC output signal which is a function of the amplitude of the input signal and the phase of the input signal with respect to a reference signal.

Z_{in} for all subtypes of the PSD is greater than 500 K ohms.

The output frequency response for all subtypes of the PSD is constant within 1 per cent for amplitude modulation rate from 0 to 60 CPS.

The reference input for all subtypes of the PSD accepts the output of either a PSD REFERENCE CONDITIONER (REC) or REFERENCE GENERATOR (REG). All G & N Phase Reference Signals are conditioned by either an REC or REG.

The PSD Subtypes and their signal range are:

Class PAD 50 - 0 to 200 mv rms through 5 v rms, 400 to 3200 CPS (cosine function)
Class PSD 51 - 0 to 5 v rms through 50 v rms, 400 to 3200 CPS (cosine function)
Class PSD 52 - 0 to 200 mv rms through 5 v rms, 400 to 3200 CPS (sine function, 90 degree phase shift)
Class PSD 53 - 0 to 5 v rms through 50 v rms, 400 to 3200 CPS (sine function, 90 degree phase shift)
Class PSD 54 - 0 to 200 mv rms through 5 v rms, 3.2 KC only (-45 degree phase shift cosine function)
Class PSD 55 - 0 to 200 mv rms through 5 v rms, 3.2 KC only (-45 degree phase shift sine function)
Class PSD 56 - 0 to 1 v rms through 5 v rms, 25.6 KC (cosine function)

The reference document for the PSD is Procurement Spec. MC 901-0283A.

REG - The PSD reference generator accepts set and reset pulses and generates a square-wave reference signal for phase sensitive demodulators.

The output reference signal for the REG Subtype is:
Class REG 3200 - 3.2 KC
Z_{in} is greater than 50 K ohms

The reference document for the REG is procurement Spec. MC 496 - 0012 - 1

REC - The PSD reference conditioners provide impedance transformation and amplification or attenuation as required for reference signals to the phase sensitive demodulators.

The input signal ranges of the REC Subtypes are:
Class REC 800 - 0.4 to 32 v rms at 800 CPS
Class REC 3200 - 0.4 to 32 v rms at 3200 CPS
Class REC 25,600 - 0.4 to 32 v rms at 25.6 KCPS

Z_{in} for all REC Subtypes is greater than 1 Megohm.

The reference document for the REC is Procurement Spec. MC 901-0362

ANC - The AC noise converter is used to monitor the noise on a DC power supply. The converter provides a 0 to +5 VDC output that is proportional to the rectified average of the noise.

The input signal range for the ANC Subtype is:
ANC 130 - 0 to 100 mv rms through 5 v rms form 50 to 10,000 CPS

The input impedance (Z_{in}) for the ANC is greater than 500 K ohms for DC signals and greater than 100 K ohms for AC signals.

The output response time for step changes at the input converges to within addition to the PB, PU, PD and CC classes defined in sections .14 and 4.14, the following signal classes are also defined:

RA - Raw Analog Voltage
RD - Raw Discrete Voltage

5.14 Measurement Scale

Range - The range, in engineering units, of the measurand, represented by voltage range defined in section 5.15 and expressed in low, nominal and high values.

Units - Engineering units of the measurand.

5.15 Electrical Characteristics

Voltage Range - The voltage range at the interface expressed in low, nominal and high values.

Zs - The source impedance looking into the MIT side of the interface at the PSA ADAPTOR.

Z_L - The load impedance looking into the GAEC side of the interface at the PSA ADAPTOR.

The source and load impedances for the "IMU TEMP. OUT OF LIMITS' discrete are defined as follows:

Zs - The source impedance looking into the MIT side of the interface at J217.

Z_L - The load impedance looking into the GAEC side of the interface at J217.

5.16 GSE Signal Conditioning

This section defines the signal conditioners on the GAEC side of the interface by type, subtype and full scale output as follows:

ACD - AC to DC Converter converts sine and square save input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the ACD is greater than 500 K ohms.

The output frequency response for all subtypes of the ACD is constant within 1 per cent for amplitude modulation rates of 0 to 60 CPS.

The ACD Subtypes and their input signal range are:
Class ACD 40 - 0 to 100 mv rms through 6 v rms from 400 to 3200 CPS
Class ACD 41 - 0 to 5 v rms through 150 v rms from 400 to 3200 CPS
Class ACD 42 - 105 v rms to 130 v rms at 400 CPS only (expanded scale)
Class ACD 43 - 0 to 100 mv rms through 5 v rms at 25.6 KCPS

The reference document for the ACD is Procurement Spec. MC 901-0278B

5.16 GSE Signal Conditioning (cont'd)

DCA - DC amplifier which converts low-level, DC input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the DCA is greater than 500 K ohms with the exception of class 05 which has an input impedance greater than 1 Megohm from 0 to 200 CPS.

The output frequency response for all subtypes of the DCA is constant within 1 per cent for input signal frequencies from 0 to 50 CPS for class 01 and 02 and from 0 to 100 CPS for class 05.

The DCA Subtypes and their input signal range are:
Class DCA 01 - 0 to +20 mv DC through 0 to +250 mv DC
Class DCA 02 - 0 to +250 mv DC through 0 to +5 VDC
Class DCA 05 - 0 to +1 VDC through 0 to +5 VDC

The reference document for the DCA is Procurement Spec. MC 901-0261A

ISA - The isolation attenuator attenuates DC input signals to proportionate 0 to +5 VDC output signals.

Z_{in} for all subtypes of the ISA is greater than 500 Kohms
The output frequency response for all subtypes of the ISA is constant

within 1 per cent for input signals from 0 to 50 CPS.

The ISA Subtypes and their input signal range are:

Class ISA 20 - 0 to +5 VDC through 0 to +50 VDC
Class ISA 22 - 0 to -5 VDC through 0 to -50 VDC

The reference document for the ISA is Procurement Spec. MC 901-0260A.

PSD - The phase-sensitive demodulator produces a 0 to +5 VDC output signal which is a function of the amplitude of the input signal and the phase of the input signal with respect to a reference signal.

Z_{in} for all subtypes of the PSD is greater than 500 K ohms.

The output frequency response for all subtypes of the PSD is constant within 1 per cent for amplitude modulation rate from 0 to 60 CPS.

The reference input for all subtypes of the PSD accepts the output of either a PSD REFERENCE CONDITIONER (REC) or REFERENCE GENERATOR (REG). All G & N Phase Reference Signals are conditioned by either an REC or REG.

The PSD Subtypes and their signal range are:
Class PAD 50 - 0 to 200 mv rms through 5 v rms, 400 to 3200 CPS (cosine function)
Class PSD 51 - 0 to 5 v rms through 50 v rms, 400 to 3200 CPS (cosine function)
Class PSD 52 - 0 to 200 mv rms through 5 v rms, 400 to 3200 CPS (sine function, 90 degree phase shift)
Class PSD 53 - 0 to 5 v rms through 50 v rms, 400 to 3200 CPS (sine function, 90 degree phase shift)
Class PSD 54 - 0 to 200 mv rms through 5 v rms, 3.2 KC only (±5 degree phase shift cosine function)
Class PSD 55 - 0 to 200 mv rms through 5 v rms, 3.2 KC only (±5 degree phase shift sine function)
Class PSD 56 - 0 to .1 v rms through 5 v rms, 25.6 KC (cosine function)

The reference document for the PSD is Procurement Spec. MC 901-0283A.

REG - The PSD reference generator accepts set and reset pulses and generates a square-wave reference signal for phase sensitive demodulators.

The output reference signal for the REG Subtype is:
Class REG 3200 - 3.2 KC
Z_{in} is greater than 50 K ohms

The reference document for the REG is procurement Spec. MC 496 - 0012 - 1

REC - The PSD reference conditioners provide impedance transformation and amplification or attenuation as required for reference signals to the phase sensitive demodulators.

The input signal ranges of the REC Subtypes are:
Class REC 800 - 0.4 to 32 v rms at 800 CPS
Class REC 3200 - 0.4 to 32 v rms at 3200 CPS
Class REC 25,600 - 0.4 to 32 v rms at 25.6 KCPS

Z_{in} for all REC Subtypes is greater than 1 Megohm.

The reference document for the REC is Procurement Spec. MC 901-0362

ANC - The AC noise converter is used to monitor the noise on a DC power supply. The converter provides a 0 to +5 VDC output that is proportional to the rectified average of the noise.

The input signal range for the ANC Subtype is:
ANC 130 - 0 to 100 mv rms through 5 v rms form 50 to 10,000 CPS

The input impedance (Z_{in}) for the ANC is greater than 500 K ohms for DC signals and greater than 100 K ohms for AC signals.

The output response time for step changes at the input converges to within

1 per cent of the steady-state value in less than 0.1 second.

The reference document for the ANC is Procurement Spec. MC 901-03'8.

GLD - The glitch detector monitors a DC power supply and indicates a received noise spike greater than a predetermined threshold level. The threshold level is adjustable and has a tolerance of ±300 mv DC. Upon receipt of a spike sufficient amplitutde, the detector indicates an "ON" condition and remains "ON" until the output is sampled and the detector is reset to the "OFF" condition by the trailing edge of the sampling pulse.

The input signal range logic levels of the GLD Subtype is:

GLD 160 - On noise spikes above threshold level to ±50 v peak maximum, the threshold level is adjustable in the range of ±1 v peak through ±5 v peak.

The input impedance of the GLD is greater than 500 K ohms.

The reference document for the GLD is Procurement Spec. MC 901-0359-1

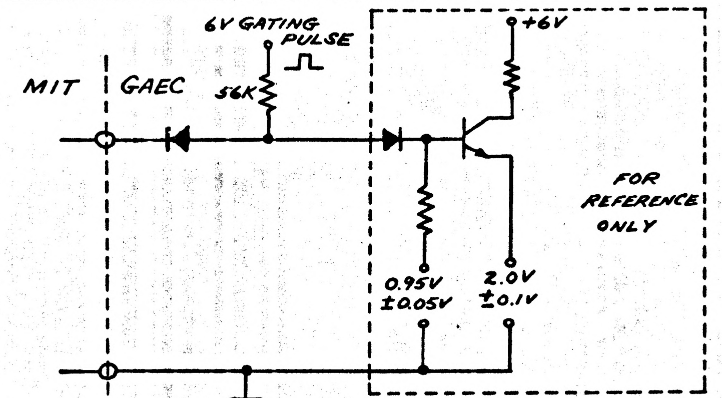
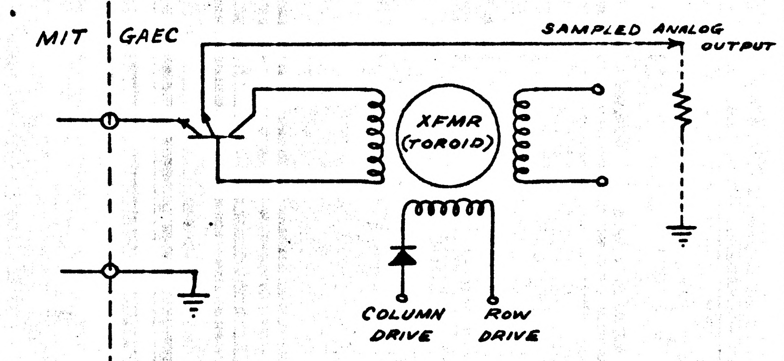

6V GATING PULSE
MIT
GAEC
56K
+6V
FOR REFERENCE ONLY
0.95V ±0.05V
2.0V ±0.1V

FIGURE 1A

TYPICAL PCM SINGLE DIODE GATE — USED AS INPUT CIRCUIT FOR PD CLASS SIGNALS


MIT
GAEC
SAMPLED ANALOG OUTPUT
XFMR (TOROID)
COLUMN DRIVE
ROW DRIVE

TYPICAL PCM HIGH LEVEL ANALOG GATE — USED AS INPUT CIRCUIT FOR PB AND PU CLASS SIGNALS

FIGURE 1B

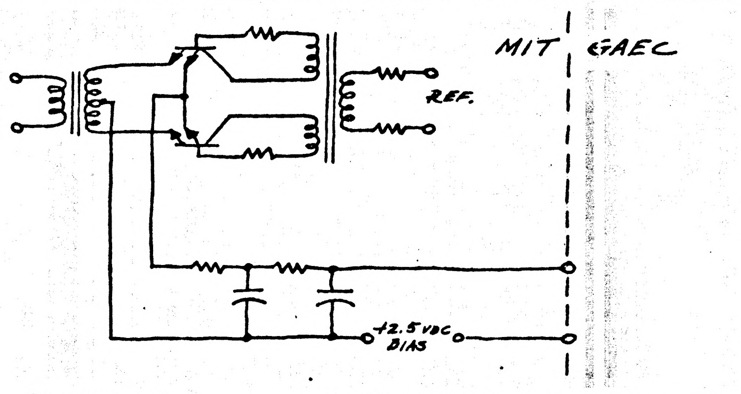

MIT
GAEC
REF.
+2.5 VDC BIAS

FIGURE 2A

TYPICAL MIT ANALOG OUTPUT CIRCUIT USED FOR PB CLASS SIGNALS

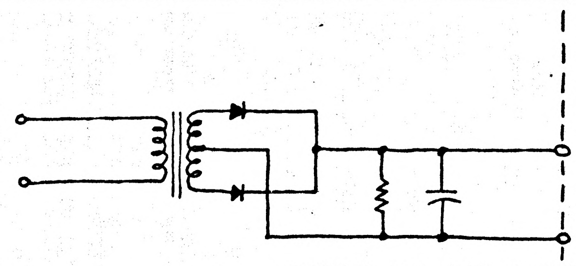


FIGURE 2B

TYPICAL MIT ANALOG OUTPUT CIRCUIT USED FOR PU CLASS SIGNALS

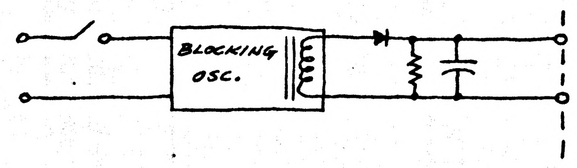
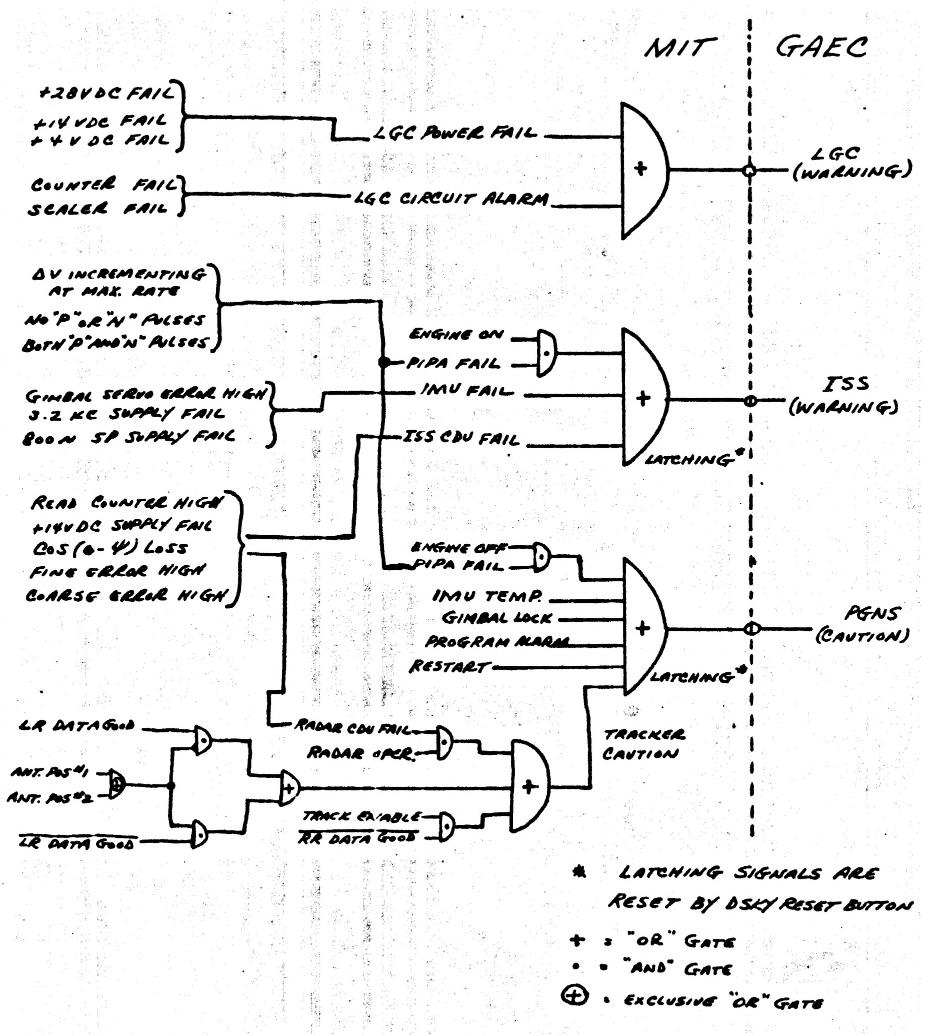

BLOCKING OSC.

FIGURE 2C

TYPICAL MIT DISCRETE OUTPUT CIRCUIT USED FOR PD CLASS SIGNALS


MIT
GAEC
+28VDC FAIL
+14VDC FAIL
+4VDC FAIL
LGC POWER FAIL
COUNTER FAIL
SCALER FAIL
LGC CIRCUIT ALARM
LGC (WARNING)
ΔV INCREMENTING AT MAX. RATE
NO "P" OR "N" PULSES
BOTH "P" AND "N" PULSES
ENGINE ON
PIPA FAIL
GIMBAL SERVO ERROR HIGH
3.2 KC SUPPLY FAIL
800 N SP SUPPLY FAIL
IMU FAIL
ISS CDU FAIL
ISS (WARNING)
LATCHING*
READ COUNTER HIGH
+14VDC SUPPLY FAIL
COS (θ-ψ) LOSS
FINE ERROR HIGH
COARSE ERROR HIGH
ENGINE OFF
PIPA FAIL
IMU TEMP.
GIMBAL LOCK
PROGRAM ALARM
RESTART
PGNS (CAUTION)
LATCHING*
LR DATA GOOD
ANT. POS #1
ANT. POS #2
$\overline{\text{LR DATA GOOD}}$
RADAR CDU FAIL
RADAR OPER.
TRACK ENABLE
$\overline{\text{RR DATA GOOD}}$
TRACKER CAUTION
* LATCHING SIGNALS ARE RESET BY DSKY RESET BUTTON
+ = "OR" GATE
• = "AND" GATE
⊕ = EXCLUSIVE "OR" GATE

FUNCTIONAL DERIVATION OF CAUTION AND WARNING OUTPUTS

FIGURE 3

1 per cent of the steady-state value in less than 0.1 second.

The reference document for the ANC is Procurement Spec. MC 901-0:78.

GLD - The glitch detector monitors a DC power supply and indicates a received noise spike greater than a predetermined threshold level. The threshold level is adjustable and has a tolerance of ±300 mv DC. Upon receipt of a spike sufficient amplitutde, the detector indicates an "ON" condition and remains "ON" until the output is sampled and the detector is reset to the "OFF" condition by the trailing edge of the sampling pulse.

The input signal range logic levels of the GLD Subtype is:

GLD 160 - On noise spikes above threshold level to ±50 v peak maximum, the threshold level is adjustable in the range of ±1 v peak through ±5 v peak.

The input impedance of the GLD is greater than 500 K ohms.

The reference document for the GLD is Procurement Spec. MC 901-0359-1

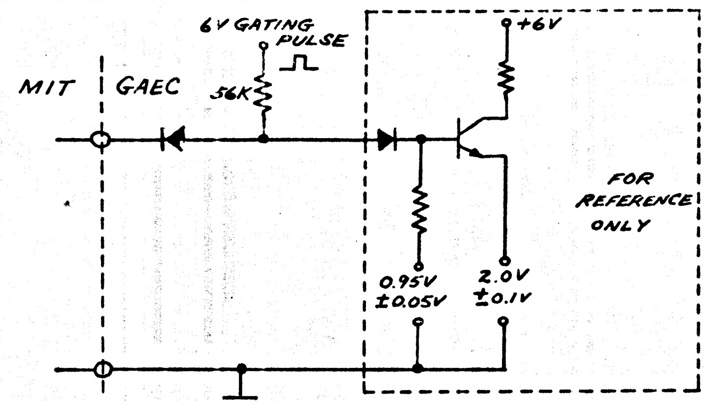

6V GATING PULSE
MIT
GAEC
56K
+6V
FOR REFERENCE ONLY
0.95V ±0.05V
2.0V ±0.1V

FIGURE 1A

TYPICAL PCM SINGLE DIODE GATE — USED AS INPUT CIRCUIT FOR PD CLASS SIGNALS

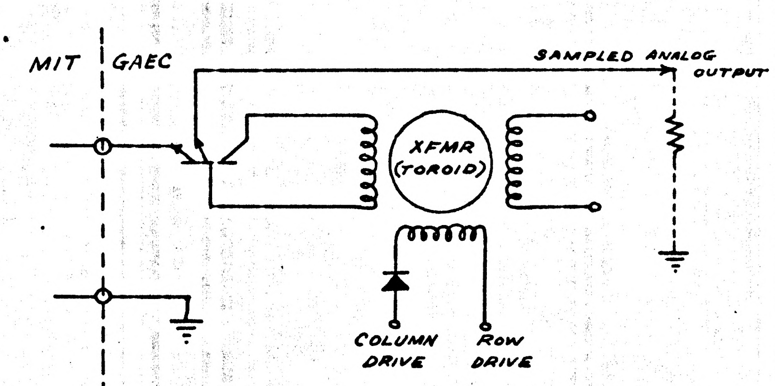

MIT
GAEC
SAMPLED ANALOG OUTPUT
XFMR (TOROID)
COLUMN DRIVE
ROW DRIVE

FIGURE 1B

TYPICAL PCM HIGH LEVEL ANALOG GATE — USED AS INPUT CIRCUIT FOR PB AND PU CLASS SIGNALS

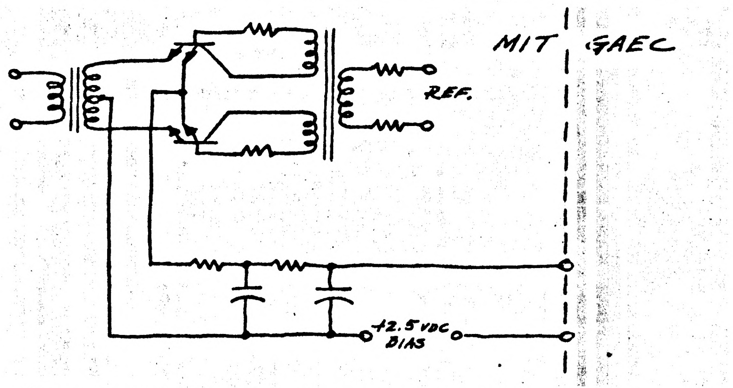

MIT
GAEC
REF.
+2.5 VDC BIAS

FIGURE 2A

TYPICAL MIT ANALOG OUTPUT CIRCUIT USED FOR PB CLASS SIGNALS

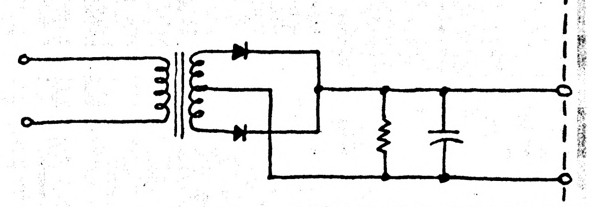


FIGURE 2B

TYPICAL MIT ANALOG OUTPUT CIRCUIT USED FOR PU CLASS SIGNALS

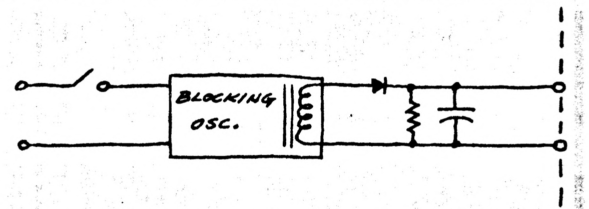
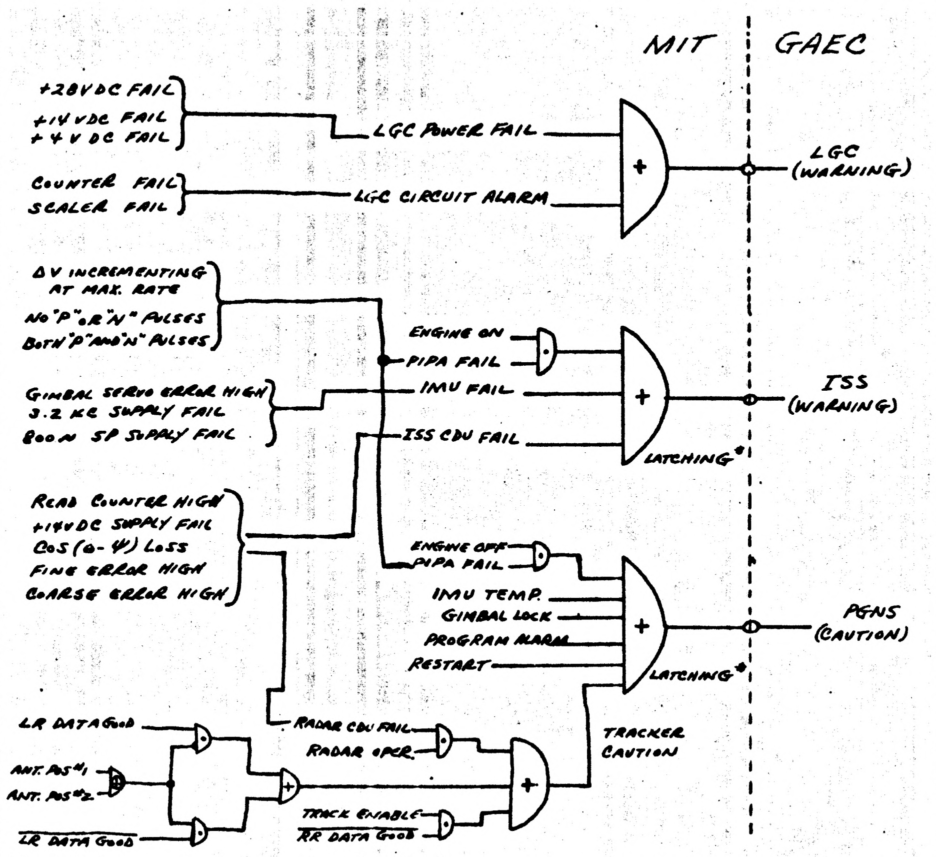

BLOCKING OSC.

FIGURE 2C

TYPICAL MIT DISCRETE OUTPUT CIRCUIT USED FOR PD CLASS SIGNALS


MIT
GAEC
+28VDC FAIL
+14 VDC FAIL
+4 V DC FAIL
LGC POWER FAIL
COUNTER FAIL
SCALER FAIL
LGC CIRCUIT ALARM
LGC (WARNING)
ΔV INCREMENTING AT MAX. RATE
NO "P" OR "N" PULSES
BOTH "P" AND "N" PULSES
ENGINE ON
PIPA FAIL
GIMBAL SERVO ERROR HIGH
3.2 KC SUPPLY FAIL
800 ~ SP SUPPLY FAIL
IMU FAIL
ISS CDU FAIL
ISS (WARNING)
LATCHING*
READ COUNTER HIGH
+14VDC SUPPLY FAIL
COS (θ-ψ) LOSS
FINE ERROR HIGH
COARSE ERROR HIGH
ENGINE OFF
PIPA FAIL
IMU TEMP.
GIMBAL LOCK
PROGRAM ALARM
RESTART
PGNS (CAUTION)
LATCHING*
LR DATA GOOD
ANT. POS #1
ANT. POS #2
$\overline{\text{LR DATA GOOD}}$
RADAR CDU FAIL
RADAR OPER.
TRACK ENABLE
$\overline{\text{RR DATA GOOD}}$
TRACKER CAUTION

* LATCHING SIGNALS ARE RESET BY DSKY RESET BUTTON

+ = "OR" GATE

• = "AND" GATE

⊕ = EXCLUSIVE "OR" GATE

FUNCTIONAL DERIVATION OF CAUTION AND WARNING OUTPUTS

FIGURE 3

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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TABLE I

ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	REMARKS
GG0001	Digital Downlink			(4) (2)		Ref. to ICD 370-10004
GG1040V	120 VDC Pulse Torque Ref.	2B	PU		VDC	
GG1110V	2.5 VDC TM Bias, PCM		PU		VDC	
GG1111V	2.5 VDC TM Bias, DF I		PU		VDC	
GG1201V	IMU 800 CPS 1P Supply		PU		VRMS	
GG1331V	28V 3.2 KC Supply		PU		VRMS	
GG1513X	IMU Standby/Off		PD		ON/OFF	
GG1523X	LGC Operate		PD		ON/OFF	
GG2001V	X Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2002V	X Pipa S/G Output, Quad		PB		VRMS	
GG1102V	X Pipa +28V DC PVR Input	2B	PU		VDC	
GG2021V	Y Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2022V	Y Pipa S/G Output, Quad		PB		VRMS	
GG1103V	Y Pipa +28 VDC PVR Input	2B	PU		VDC	
GG2041V	Z Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2042 V	Z Pipa S/G Output, Quad		PB		VRMS	
GG1104V	Z Pipa +28 VDC PVR Input	2B	PU		VDC	
GG2107V	IG Servo Error, In Phase	2A	PB		VRMS	

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ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	REMARKS
GG2110C	IG Torque Motor Current	2A	PB	(4) (2)	AMPS	
GG2112V	IG 1x Resolver Sin		PB		Radians	
GG2113V	IG 1x Resolver Cos		PB		Radians	
GG2137V	MG Servo Error, In Phase		PB		VRMS	
GG2140C	MG Torque Motor Current		PB		AMPS	
GG2142V	MG 1x Resolver Sin		PB		Radians	
GG2143V	MG 1x Resolver Cos		PB		Radians	
GG2167V	OG Servo Error, In Phase		PB		VRMS	
GG2170C	OG Torque Motor Current		PB		AMPS	
GG2172V	OG 1x Resolver Sin		PB		Radians	
GG2173V	OG 1x Resolver Cos		PB		Radians	
GG2219V	Pitch CDU DAC Output		PB		VRMS	
GG2279V	Roll CDU DAC Output		PB		VRMS	
GG2249V	Yaw CDU DAC Output		PB		VRMS	
GG2300T	Pipa Temp.	2B	PU		Deg. F	
GG2301T	IRIG Temp..	2B	PU		Deg. F	

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ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANCE	MEASUREMENT SCALE UNITS	REMARKS
GG3104V	RR Shaft 1xResolver Sin	2A	PB	(4) (2)	Radians	
GG3105V	RR Shaft 1x Resolver Cos		PB		Radians	
GG3124V	RR Trun 1x Resolver Sin		PB		Radians	
GG3125V	RR Trun 1x Resolver Cos		PB		Radians	
GG6020T	Pipa Cal. Mod. Temp.	2B	PU		Deg. F	
GG9001X	LGC (Warning)		CC		ON/OFF	See ICD #LIS 370-10004
GG9002X	IMS (Warning)		CC		ON/OFF	
GG9003X	PGNS (Caution		CC		ON/OFF	
GG2220 V	IG CDU Fine Error	2A	PB		VRMS	
GG2250 V	MG CDU Fine Error		PB			
GG2280V	OG CDU Fine Error		PB			
GG3344V	RR Shaft 16x Resolver Sin		PB		Radians	
GG3345V	RR Shaft 16x Resolver Cos		PB		Radians	
GG3364V	RR Trun 16x Resolver Sin		PB		Radians	
GG3365V	RR Trun 16x Resolver Cos		PB		Radians	
GG3310V	RR Shaft CDU Fine Error		PB		VRMS	
GG3320V	RR Trun CDU Fine Error		PB			
GG2302 X	IMU Heater On	2C	PU/PD		ON/OFF	PU for DFI
GG2303 X	IMU Blower On		PU/PD		ON/OFF	PD for PCM
GG3309V	RR Shaft CDU DAC Output	2A	PB		VRMS	
GG3319V	RR Trun CDU DAC Output	2A	PB		VRMS	

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TABLE II

ID	MEASUREMENT NOMENCLATURE	LRE USED IN	STIMULI CHARACTERISTICS RANGE	STIMULI CHARACTERISTICS Z_S	STIMULI CHARACTERISTICS Z_L	CLASS	REMARKS
	Pipa Ref Select	PSA Adap.	NA	(4) (1)	(4) (1)	cc	
	X Pipa Select	PSA Adap.				cc	
	Y Pipa Select	PSA Adap.				cc	
	Z Pipa Select	PSA Adap.				cc	
	IG Step Input	PSA				cc	
	MG Step Input	PSA				cc	
	OG Step Input	PSA				cc	
	LGC Margin Test Enable	LGC				cc	
	GSE Input to LGC +14 VDC Sup.	LGC	-30VDC to +30VDC				
	GSE Input to LGC +4 VDC Sup.	LGC	-30VDC to +30VDC				

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ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	REMARKS
GG0001	Digital Downlink			(4) (2)		Ref. to ICD 370-10004
GG1040V	120 VDC Pulse Torque Ref.	2B	PU		VDC	
GG1110V	2.5 VDC TM Bias, PCM		PU		VDC	
GG1111V	2.5 VDC TM Bias, DF I		PU		VDC	
GG1201V	IMU 800 CPS 1P Supply		PU		VRMS	
GG1331V	28V 3.2 KC Supply		PU		VRMS	
GG1513X	IMU Standby/Off		PD		ON/OFF	
GG1523X	LGC Operate		PD		ON/OFF	
GG2001V	X Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2002V	X Pipa S/G Output, Quad		PB		VRMS	
GG1102V	X Pipa +28V DC PVR Input	2B	PU		VDC	
GG2021V	Y Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2022V	Y Pipa S/G Output, Quad		PB		VRMS	
GG1103V	Y Pipa +28 VDC PVR Input	2B	PU		VDC	
GG2041V	Z Pipa S/G Output, In Phase	2A	PB		VRMS	
GG2042 V	Z Pipa S/G Output, Quad		PB		VRMS	
GG1104V	Z Pipa +28 VDC PVR Input	2B	PU		VDC	
GG2107V	IG Servo Error, In Phase	2A	PB		VRMS	

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TABLE I

ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	REMARKS
GG2110C	IG Torque Motor Current	2A	PB	(4) (2)	AMPS	
GG2112V	IG 1x Resolver Sin		PB		Radians	
GG2113V	IG 1x Resolver Cos		PB		Radians	
GG2137V	MG Servo Error, In Phase		PB		VRMS	
GG2140C	MG Torque Motor Current		PB		AMPS	
GG2142V	MG 1x Resolver Sin		PB		Radians	
GG2143V	MG 1x Resolver Cos		PB		Radians	
GG2167V	OG Servo Error, In Phase		PB		VRMS	
GG2170C	OG Torque Motor Current		PB		AMPS	
GG2172V	OG 1x Resolver Sin		PB		Radians	
GG2173V	OG 1x Resolver Cos		PB		Radians	
GG2219V	Pitch CDU DAC Output		PB		VRMS	
GG2279V	Roll CDU DAC Output		PB		VRMS	
GG2249V	Yaw CDU DAC Output		PB		VRMS	
GG2300T	Pipa Temp.	2B	PU		Deg. F	
GG2301T	IRIG Temp..	2B	PU		Deg. F	

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ID	MEASUREMENT NOMENCLATURE	MIT OUTPUT CIRCUIT	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	REMARKS
GG3104V	RR Shaft 1xResolver Sin	2A	PB	(4) (2)	Radians	
GG3105V	RR Shaft 1x Resolver Cos		PB		Radians	
GG3124V	RR Trun 1x Resolver Sin		PB		Radians	
GG3125V	RR Trun 1x Resolver Cos		PB		Radians	
GG6020T	Pipa Cal. Mod. Temp.	2B	PU		Deg. F	
GG9001X	LGC (Warning)		CC		ON/OFF	See ICD #LIS 370-10004
GG9002X	LAS (Warning)		CC		ON/OFF	
GG9003X	PGNS (Caution		CC		ON/OFF	
GG2220 V	IG CDU Fine Error	2A	PB		VRMS	
GG2250 V	MG CDU Fine Error		PB			
GG2280V	OG CDU Fine Error		PB			
GG3344V	RR Shaft 16x Resolver Sin		PB		Radians	
GG3345V	RR Shaft 16x Resolver Cos		PB		Radians	
GG3364V	RR Trun 16x Resolver Sin		PB		Radians	
GG3365V	RR Trun 16x Resolver Cos		PB		Radians	
GG3[illegible]V	RR Shaft CDU Fine Error		PB		VRMS	
GG3[illegible]V	RR Trun CDU Fine Error		PB			
GG2302 X	IMU Heater On	2C	PU/PD		ON/OFF	PU for DFI
GG2303 X	IMU Blower On		PU/PD		ON/OFF	PD for PCM
GG3309V	RR Shaft CDU DAC Output	2A	PB		VRMS	
GG3319V	RR Trun CDU DAC Output	2A	PB		VRMS	

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TABLE II

ID	MEASUREMENT NOMENCLATURE	LRE USED IN	STIMULI CHARACTERISTICS RANGE	STIMULI CHARACTERISTICS Z_S	STIMULI CHARACTERISTICS Z_L	CLASS	REMARKS
	Pipa Ref Select	PSA Adap.	NA	(4) (1)	(4) (1)	cc	
	X Pipa Select	PSA Adap.				cc	
	Y Pipa Select	PSA Adap.				cc	
	Z Pipa Select	PSA Adap.				cc	
	IG Step Input	PSA				cc	
	MG Step Input	PSA				cc	
	OG Step Input	PSA				cc	
	LGC Margin Test Enable	LGC				cc	
	GSE Input to LGC +14 VDC Sup.	LGC	-30VDC to +30VDC				
	GSE Input to LGC +4 VDC Sup.	LGC	-30VDC to +30VDC				

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TABLE III

ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	ELECTRICAL CHARACTERISTICS VOLTAGE RANGE	Z_S	Z_L	GSE SIGNAL CONDITIONING TYPE	SUB TYPE	FULL SCALE	REMARKS
NG1501V	IMU Oper. +28 VDC Noise RMS	(4)(2)	(4)(2)	VRMS	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1502X	IMU Oper. +28 VDC Noise, Peaks			GL							
GG1510V	IMU Stnby +28 VDC, Level			VDC							
NG1511V	IMU Stnby +28 VDC Noise, RMS			VRMS							
NG1512X	IMU Stnby +28 VDC Noise, Peaks			GL							
GG1520V	LGC Oper. +28 VDC, Level			VDC							
NG1521V	LGC Oper. +28 VDC Noise, RMS			VRMS							
NG1522X	LGC Oper. +28 VDC Noise, Peaks			GL							
GG2011V	X Pipa Mode Check			VRMS			1M				Hardline Switched
GG2031V	Y Pipa Mode Check			VRMS			(4)(1)				
GG2051V	Z Pipa Mode Check			VRMS							
GG2106V	IG Servo Error, Total			VRMS							
GG2110C	IG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2136V	MG Servo Error, Total			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2140C	MG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2166V	OG Servo Error, Total			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG217 C	OG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2220V	IG CDU Fine Error			(4)(2)			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2221V	IG CDU Coarse Error										
GG2250V	MG CDU Fine Error										
GG2251V	MG CDU Coarse Error										
GG2280V	OG CDU Fine Error										
GG2281V	OG CDU Coarse Error										
GG2301T	Irig Temp.			Deg. F.							

TABLE III

ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	ELECTRICAL CHARACTERISTICS VOLTAGE RANGE	Z_S	Z_L	GSE SIGNAL CONDITIONING TYPE	SUB TYPE	FULL SCALE	REMARKS
GG2302X	IMU Heater Current On	(4)(2)	(4)(2)	(4)(2)	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2303X	IMU Blower Current On										
GG3311V	Shaft Fine Error										
GG3312V	Shaft CDU Coarse Error										
GG3321V	Trun Fine Error										
GG3322V	Trun CDU Coarse Error										
GG4300T	LGC Temp			D 3. F							
GG602 T	Cal Mod Temp.			Deg.F							
GG6021T	PSA Temp.			Deg. F							
	IMU Temp. Out of Limits			(4)(2)	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	

TABLE III

ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE RANGE	MEASUREMENT SCALE UNITS	ELECTRICAL CHARACTERISTICS VOLTAGE RANGE	Z_S	Z_L	GSE SIGNAL CONDITIONING TYPE	SUB TYPE	FULL SCALE	REMARKS
GG1020V	LGC +14 VDC Supply, Level	(4)(2)	(4)(2)	VDC	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1021V	LGC +14 VDC Supply Noise, RMS			VRMS							
NG1022X	LGC +14 VDC Supply Noise, Peaks			GL							
GG1030V	LGC + 4 VDC Supply, Level			VDC							
NG1031V	LGC + 4 VDC Supply Noise, RMS			VRMS							
NG1032X	LGC + 4 VDC Supply Noise, Peaks			GL							
GG1070V	CDU + 4 VDC Supply, Level			VDC			500K	DCA			
NG1071V	CDU + 4 VDC Supply Noise, RMS			VRMS			500K	ANC			
NG1072X	CDU + 4 VDC Supply Noise, Peaks			GL			500K	GLD			
GG1050V	20 VDC SCA Supply			VDC			(4)(1)	(4)(1)			
GG1100V	-28 VDC Supply			VDC							
GG1202V	800 CPS 5P -90° Supply			VRMS			500K	ACD	41	35	
GG1203V	800 CPS 5P 0° Supply			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1336B	3.2 KC 1P LGC Sync, Phase										
GG1331V	3.2 Butterfly Ref.			VRMS							Hardline Switched
GG1500V	IMU Oper. +28 VDC Level			VDC							

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TABLE III

ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE		ELECTRICAL CHARACTERISTICS			GSE SIGNAL CONDITIONING			REMARKS
			RANGE	UNITS	VOLTAGE RANGE	Z_S	Z_L	TYPE	SUB TYPE	FULL SCALE	
GG1020V	LGC +14 VDC Supply, Level	(4)(2)	(4)(2)	VDC	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1021V	LGC +14 VDC Supply Noise, RMS			VRMS							
NG1022X	LGC +14 VDC Supply Noise, Peaks			GL							
GG1030V	LGC + 4 VDC Supply, Level			VDC							
NG1031V	LGC + 4 VDC Supply Noise, RMS			VRMS							
NG1032X	LGC + 4 VDC Supply Noise, Peaks			GL							
GG1070V	CDU + 4 VDC Supply, Level			VDC			500K	DCA			
NG1071V	CDU + 4 VDC Supply Noise, RMS			VRMS			500K	ANC			
NG1072X	CDU + 4 VDC Supply Noise, Peaks			GL			500K	GLD			
GG1050V	20 VDC SCA Supply			VDC			(4)(1)	(4)(1)			
GG1100V	-28 VDC Supply			VDC							
GG1202V	800 CPS 5P -90° Supply			VRMS			500K	ACD	41	35	
GG1203V	800 CPS 5P 0° Supply			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1336B	3.2 KC 1P LGC Sync, Phase										
GG1331V	3.2 Butterfly Ref.			VRMS							Hardline Switched
GG1500V	IMU Oper. +28 VDC Level			VDC							

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ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE		ELECTRICAL CHARACTERISTICS			GSE SIGNAL CONDITIONING			REMARKS
			RANGE	UNITS	VOLTAGE RANGE	Z_S	Z_L	TYPE	SUB TYPE	FULL SCALE	
NG1501V	IMU Oper. +28 VDC Noise RMS	(4)(2)	(4)(2)	VRMS	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
NG1502X	IMU Oper. +28 VDC Noise, Peaks			GL							
GG1510V	IMU Stnby +28 VDC, Level			VDC							
NG1511V	IMU Stnby +28 VDC Noise, RMS			VRMS							
NG1512X	IMU Stnby +28 VDC Noise, Peaks			GL							
GG1520V	LGC Oper. +28 VDC, Level			VDC							
NG1521V	LGC Oper. +28 VDC Noise, RMS			VRMS							
NG1522X	LGC Oper. +28 VDC Noise, Peaks			GL							
GG2011V	X Pipa Mode Check			VRMS			1M				Hardline Switched
GG2031V	Y Pipa Mode Check			VRMS			(4)(1)				
GG2051V	Z Pipa Mode Check			VRMS							
GG2106V	IG Servo Error, Total			VRMS							
GG2110C	IG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2136V	MG Servo Error, Total			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2140C	MG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2166V	OG Servo Error, Total			VRMS			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2170C	OG Torque Motor Current			AMPS			500K	DCA	05	5VDC	
GG2220V	IG CDU Fine Error			(4)(2)			(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2221V	IG CDU Coarse Error										
GG2250V	MG CDU Fine Error										
GG2251V	MG CDU Coarse Error										
GG2280V	OG CDU Fine Error										
GG2281V	OG CDU Coarse Error										
GG2301T	Irig Temp.			Deg. F.							

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

INTERFACE CONTROL DOCUMENT

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TABLE III

ID	MEASUREMENT NOMENCLATURE	CLASS	MEASUREMENT SCALE		ELECTRICAL CHARACTERISTICS			GSE SIGNAL CONDITIONING •			REMARKS
			RANGE	UNITS	VOLTAGE RANGE	Z_S	Z_L	TYPE	SUB TYPE	FULL SCALE	
GG2302X	IMU Heater Current On	(4)(2)	(4)(2)	(4)(2)	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	
GG2303X	IMU Blower Current On										
GG3311V	Shaft Fine Error										
GG3312V	Shaft CDU Coarse Error										
GG3321V	Trun Fine Error										
GG3322V	Trun CDU Coarse Error										
GG4300T	LGC Temp			Deg. F							
GG6002T	Cal Mod Temp.			Deg. F							
GG6021T	PSA Temp.			Deg. F							
	IMU Temp. Out of Limits			(4)(2)	(4)(2)	(4)(2)	(4)(1)	(4)(1)	(4)(1)	(4)(1)	

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AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	1/26/68
W. Stameris	MIT/IL	20 Nov 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100
Exhibit E
Para. 5.6.2

Line Item 13
Primary No 697
Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: LIS 370-10004B-14
Sheet 1 of 1

ICRA NO: 10-147
Sheet 2 of 2

ICD NO. LIS 370-10004 B

CCA NO.

DATE 1-26-68

ICD TITLE
LGC LEM Electrical Interface

IDRR 36676

AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Sheet 14 Signals N3 and N4. In remarks column

IS: Peak current drain ~~drain~~ at 3.1 amp max for 10 seconds max (lamp test only)

WAS: Peak current drain 2.5 amp max (lamp test only)

REASON: Permit additional DSKY annunciators

DRAWN BY: W. Stameris

[illegible] 37.3 1-64

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J A LaMarine	GAEC	1/26/68
W. Stameris	MIT/IL	~~21 Dec 1967~~ 26 Jan 68

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: Sheet 1 of 1 LIS 370-10004 - B-13

ICRA NO: Sheet 2 of 2 10-148 (REVISED)

ICD NO. LIS 370-10004B

CCA NO. DATE 1-26-68

ICD TITLE LGC-LM Electrical Interface

TDRR 36676

AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Sheet 12 signal H-5 Sync Signal amplitude
change "7±3" to "****7±3"

Below Note ** add the following:
"Note **** the amplitude of the Synch signal may decrease to 3.5 volts for 150 microseconds when the LGC is switched from STANDBY TO OPERATE." This can cause a loss of PCM telemetry for up to one second.

REASON:

DRAWN BY W. Stameris

ENG 27.3 1-66

16

TDRR 24050 NOV ~~91~~ 1965

REV A

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

NAS 9-1100
Exhibit E
Para. 5.6.2
Line Item 13
Primary No. 6
Type II

INTERFACE CONTROL DOCUMENT

ICD NO. LIS 370-10004

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
Perry L Gardner	GAEC	1/8/65
Arnold B. Whitaker	GAEC	1/8/65
	MIT	

PREPARED BY: H. Donnelly/S. Glasser

CHECKED: G. Henderson G Henderson 1/5/65

TITLE:
LGC-LEM ELECTRICAL INTERFACE

CCA NO.

EFFECTIVITY

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	SHEET 1 OF 45	LIS 370-10004	A

INTERFACE CONTROL DOCUMENT

TDRR 24050 NOV 91 1965

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
				H Donnelly	GAEC		
					GAEC		
					MIT		
A	-1	12 25 37	DSKY Dimmer Circuit				
A	-2	20 21 22 23	Pulse Transformer Specification				
A	-3	ALL	General Revision and Update				
A	-4	28 29	Radar Pulse Timing				
A	-5	12 37	AGS Digital Data (Downlink)				
A	-6	6 8 33 34 35	Re-identification of RCS Jets				
A	-7	14 29	LMP Warning (MIT)				
A	-8	11	LMP Warning (GAEC)				

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
	2 OF 45	LIS 370-10004	A

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

KEY: Responsibility is identified herein as follows:

① Grumman Aircraft Engineering Corporation
Bethpage, L. I., New York

② Massachusetts Institute of Technology
Cambridge, Massachusetts

③ National Aeronautics and Space Administration
Manned Spacecraft Center

④ Design data to be supplied by:

TDRR 24050 NOV 91 1965

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

TDRR 24050 NOV 91 1965

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Section I: Signal Identification
Section II: Interface Circuitry
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  Ckt. 2: D.C. Discrete Switching (Solid State Switch)
  Ckt. 3: D.C. Discrete Switching (DSKY RELAYS)
  Ckt. 4: Attitude Hand Controller
  Ckt. 5: RCS Jet Discretes
  Ckt. 6: Pulse Interface Circuit
  Ckt. 7: PCMTE Outputs
  Ckt. 8: PCMTE Serial Digital Data Input
  Ckt. 9: PCMTE 1024 kc Sync-Signal Input
  Ckt. 10: Radar Pulse Inputs
  Ckt. 11: Radar Pulse Outputs
  Ckt. 12: LEM Mission Programmer Command Word
  Ckt. 13: DSKY Illumination
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  Figure 4: Uplink Timing
  Figure 5: Altitude and Altitude Rate
Section IV: Interface Wire Signal Identification

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
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INTRODUCTION

This ICD defines the electrical signal interface between the LEM Guidance Computer (LGC), including the DSKY, and LEM Spacecraft subsystems. The interface through which spacecraft prime power is supplied to the LGC, and the LGC-DSKY interface (GAEC cabling) are included for reference only; defining documents are LIS-390-10002 and LID-390-10001, respectively.

This ICD is divided into four sub-sections. Section I is a tabulation which identifies the signals involved in the LGC-LEM interface and specifies their electrical characteristics as measured at the interface. For the purposes of this tabulation, the "0" condition is defined as that condition which normally yields the minimum r.m.s. current flow through a given wire of the interface, and the "1" condition is defined as that which normally yields the maximum r.m.s current flow through a given wire of the interface. The nomenclature used in describing the pulse signal characteristics is defined in Figure 1. (Sheet 29).

Section II identifies the electrical circuitry on either side of the interface to a degree sufficient to clarify the nature of the signals as measured at the interface. The interface circuit used for a given signal is indicated by the "REFERENCE CIRCUIT: column in the above tabulation, in which the circuit numbers of Section II are noted. The noise limits referred to for a given interface circuit are those which could be attained without affecting the proper functioning of the interface. As a general rule, however, the interference emanating from either side of the interface shall not exceed the limits specified in MIL-I-26600/MSC-EMI-10A. The susceptibility of the respective equipments on either side of the interface shall meet the requirements of the same specifications.

Section III defines the time relationships required between signals for the transmission of digital data, at the interface. Waveform nomenclature is also defined in this section, as noted above.

Section IV identifies signals and signal returns with assigned pin numbers, wire sizes and shielding configuration at the interface. For those discrete interfaces for which a common voltage source is provided, the sizes of the isolation resistors are also noted. Note that the wiring and bundling configurations in this section are provided for information purposes only, the controlling document being LID-390-10001.

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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TDRR 24050 NOV 9 1 1965

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE					
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS					
A	CONTROL MODE AND STATUS SIGNALS														
1.	Automatic Mode	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Note 1: Source impedance (switch closure) for all signals on this sheet include LGC isolation resistor
2.	Attitude Hold Mode	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
3.	Out of Detent	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
4.	Start Abort Program	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
5.	Start Abort/Stage Program	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
6.	Engine Armed	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
7.	Digital Autopilot In Control	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
8.	In Auto Throttle	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
9.	Rate of Descent Bar	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
10.	Rate of Descent Discrete	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
11.	Rate of Descent Discrete	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
12.	Display Inertial Data	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
13.	Horizontal Velocity Low Scale	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Not Connected
14.	Block Upling	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
15.	Thrusters 4D and 4S Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
16.	Thruster 3U and 3S Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
17.	Thrusters 4U and 4F Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
18.	Thrusters 3D and 3F Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
19.	Thrusters 1D and 1S Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
20.	Thrusters 1U and 1F Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
21.	Thrusters 2U and 2S Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
22.	Thrusters 2D and 2F Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
23.	Stage Verified (status)	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
24.	4 Jet Select (Pitch & Roll)	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Not Connected
25.	Mark X	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
26.	Mark Y	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Switches located on/near
27.	Mark Bar	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	AOT; GAEC to provide
28.	Reject Mark	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Inter-connecting wiring

INTERFACE CONTROL DOCUMENT	LGC-LEM ELECTRICAL INTERFACE	SHEET 6 OF 45	ICD NO. LIS 370-10004	REV A

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

TDRR 24050 NOV 9 1 1965

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C		PULSE						SOURCE IMPEDANCE±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC.	KPPS	OHMS	OHMS	OHMS	OHMS	
B	TRANSLATION HAND CONTROLLER														
1.	+ X Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	Source Impedance (Switch Closure) for translation commands includes LGC isolation resistor.
2.	- X Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
3.	+ Y Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
4.	- Y Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
5.	+ Z Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
6.	- Z Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
C	ATTITUDE HAND CONTROLLER														
1.	Pitch Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	-	20K *	-	Hand Controller Signals are 800 analog inputs to computer. *See Ckt. 4 for signal characteristics.
2.	Roll Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	-	20K *	-	
3.	Yaw Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	-	20K *	-	
D	MAIN ENGINE SIGNALS														
1.	Increase Throttle	6	-	-	7±3	3±1	20	4	0.2	3.2	100	10 (10mh)	200	20 (20mh.)	Figure in parenthesis is inductance of transformer winding "seen" at interface
2.	Decrease Throttle	6	-	-	7±3	3±1	20	4	0.2	3.2	100	10 (10mh)	200	20 (20mh,)	
3.	Engine On	2A	3±2	28±11	-	-	-	-	-	-	<3K	>500K	> 15K	>15K	
4.	Engine Off	2A	3±2	28±11	-	-	-	-	-	-	<3K	>500K	> 15K	>15K	
5.	+ Pitch Trim	2B	5±3	18±3	-	-	-	-	-	-	<3K	>500K	7K	7K	
6.	- Pitch Trim	2B	5±3	18±3	-	-	-	-	-	-	<3K	>500K	7K	7K	
7.	+ Roll Trim	2B	5±3	18±3	-	-	-	-	-	-	<3K	>500K	7K	7K	
8.	- Roll Trim 2	2B	5±3	18±3	-	-	-	-	-	-	<3K	>500K	7K	7K	
9.	Pitch Gimbal Off	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Source Impedance includes LGC Isolation Resistor of
10.	Roll Gimbal Off	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	

INTERFACE CONTROL DOCUMENT	LGC-LEM ELECTRICAL INTERFACE	SHEET 7 OF 45	ICD NO. LIS 370-10004	REV A

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE. L. I., NEW YORK

IDRR 24050 NOV 1 1965

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C. "1"	D.C. "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP. RATE	SOURCE IMPEDANCE±10% "1"	SOURCE IMPEDANCE±10% "0"	LOAD IMPEDANCE±10% "1"	LOAD IMPEDANCE±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
E	RCS JET DISCRETES														
1.	RCS Jet 4D (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
2.	RCS Jet 3D (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
3.	RCS Jet 2D (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
4.	RCS Jet 1D (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
5.	RCS Jet 3U (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
6.	RCS Jet 2U (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
7.	RCS Jet 4U (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
8.	RCS Jet 1U (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
9.	RCS Jet 2S (+Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
10.	RCS Jet 1S (+Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
11.	RCS Jet 4S (-Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
12.	RCS Jet 3S (-Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
13.	RCS Jet 2F (+Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
14.	RCS Jet 3F (+Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
15.	RCS Jet 4F (-Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
16.	RCS Jet 1F (-Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	

INTERFACE CONTROL DOCUMENT | LGC- LEM ELECTRICAL INTERFACE | SHEET 8 OF 45 | ICD NO. LIS 370-10004 | REV A

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE. L. I., NEW YORK

IDRR 24050 NOV 1 1965

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C. "1"	D.C. "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP. RATE	SOURCE IMPEDANCE±10% "1"	SOURCE IMPEDANCE±10% "0"	LOAD IMPEDANCE±10% "1"	LOAD IMPEDANCE±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
F	RENDEZVOUS RADAR SIGNALS														
1.	RR in "1" (Data Flow)	11	-	-	7±3	4±2	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20 (20mh)	See sheet #28 for Digital Readout timing.
2.	RR in "0" (Data Flow)	11	-	-	7±3	4±2	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20 (20mh)	
3.	RR Reset Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20 (20mh)	"Loads" in parentheses are inductance of transformer winding "seen" at interface.
4.	RR Range Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20 (20mh)	
5.	RR Range Rate Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20 (20mh)	
6.	RR Counter Readout Command	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20 (20mh)	
7.	RR Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
8.	RR Power On & Auto Mode	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
9.	RR Range Low Scale	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
10.	Auto Angle Track Enable	38	④ ①	④ ①	-	-	-	-	-	-	Closure	Open	④ ①	④ ①	Relay in DSKY
G	LANDING RADAR SIGNALS														
1.	LR Reset Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	See Sheet 28 for Digital Readout timing.
2.	LR Range Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
3.	LR X_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	"Loads in parentheses are inductance of transformer winding"seen" at interface.
4.	LR Y_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
5.	LR Z_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
6.	LR Counter Readout Command	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
7.	LR in "1" (Data Flow)	11	-	-	7±3	4±2.5	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	
8.	LR in "0" (Data Flow)	11	-	-	7±3	4±2	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	
9.	LR Range Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
10	LR Antenna Position #1	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	

INTERFACE CONTROL DOCUMENT | LGC-LEM ELECTRICAL INTERFACE | SHEET 9 OF 45 | ICD NO. LIS 370-10004 | REV A

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NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C "1"	D.C "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP.RATE	SOURCE IMPEDANCE±10% "1"	SOURCE IMPEDANCE±10% "0"	LOAD IMPEDANCE±10% "1"	LOAD IMPEDANCE±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
G	Landing Radar Signals														
11.	LR Antenna Position #2 Indication	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
12.	LR Velocity Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
13.	LR Range Low Scale Factor	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
14.	LR Antenna Position Command	3C	23±10	0±2	-	-	-	-	-	-	Closure	Open	22K	22K	Relay in DSKY
H	Telemetry (Down Link)														
1.	Start Pulse	7	-	-	4,5±1	4±1	-	0	0.3	50pps	100	100	200	20(20mh) S	See sheet #30 for Digital Readout Timing.
2.	Stop Pulse	7	-	-	4.5±1	4±1	-	0	0.3	50pps	100	100	200	20(20mh)	
3.	Bit Sync Pulse	7	-	-	4.5±1	4±1	-	0	0.3	2 at 51.2	100	100	200	20(20mh)	40 pulses, 50times/sec.
4.	Serial Digital Data	8	-	-	7±2	*	20	6	0.2	**	100	10(10mh)	500	500	
5.	Sync Signal	9	-	-	7±3	0.5±0.25	-	4	0.2	1024	100	10(10mh)	100	100	Frequency Stability,±2ppm.
NOTE:	*Same as Bit Sync Pulse ** As command by Bit Sync and Data														
I	Caution and Warning Signals														
1.	LGC (Warning)	3A	0±2	28±11	-	-	-	-	-	-	Closure	Open	> 50K	>50K	Relay in DSKY ***
2.	PGNS (Caution	3A	0±2	28±11	-	-	-	-	-	-	Closure	Open	> 50K	>50K	Relay in DSKY ***
3.	INRTL Ref (Warning)	3A	0±2	28±11	-	-	-	-	-	-	Closure	Open	> 50K	>50K	Relay in DSKY ***
NOTE:	*** Computer Lamp Test will provide these closures to C & W.														

INTERFACE CONTROL DOCUMENT | LGC-LEM ELECTRICAL INTERFACE | SHEET 10 OF 45 | ICD NO. LIS 370-10004 | REV A

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NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C. "1"	D.C. "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP.RATE	SOURCE IMPEDANCE±10% "1"	SOURCE IMPEDANCE±10% "0"	LOAD IMPEDANCE±10% "1"	LOAD IMPEDANCE±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
J	LEM MISSION PROGRAMMER SIGNALS														
1.	Out "0" 1(command word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	Repetition 6 words/sec max. Differential time for the appearance of all bits for the command word is 1ms.max
2.	Out "0"2 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	> 10K	10K	> 10K	
3.	Out "0"3 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	> 10K	10K	> 10K	
4.	Out "0"4 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	> 10K	10K	> 10K	
5.	Out "0"5 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	> 10K	10K	>10K	
6.	Out "0"6 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
7.	Out "0"7 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
8.	Out "0"8 (Command Word)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
9.	Out "0" 12 (Enable)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	All "ones" indicate IMP word.
10.	Out "0" 13 (Enable)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
11.	Out "0" 14 (Enable)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
12.	Out "0" 15 (Enable)	12	8±2	28±6	-	$(24\pm^{6}_{4})10^{3}$	-	-	3000max.	-	< 2K	>10K	10K	>10K	
13.	Uplink Data Binary "1"	6	-	-	7±3	3±1	20	4	0.2	1	100	10(10mh)	200	20(20mh)	See sheet 31 for uplink timing. Also tied to SCM for ACE Uplink.
14.	Uplink Data Binary "0"	6	-	-	7±3	3±1	20	4	0.2	1	100	10(10mh)	200	20(20mh)	
15.	INRTL Ref. (Warning)	3A	0±2	18±2	-	-	-	-	-	-	Closure	Open	>300	>300	
16.	LGC (Warning)	3A	0±2	18±2	-	-	-	-	-	-	Closure	Open	>300	>300	
K	MONITOR SIGNALS														
1.	Monitor (+)														Not Connected.
2.	Monitor (-)														Not Connected.

INTERFACE CONTROL DOCUMENT | LGC-LEM ELECTRICAL INTERFACE | SHEET 11 OF 45 | ICD NO. LIS 370-10004 | REV A

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NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C		PULSE						SOURCE IMPEDANCE±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP°RATE	"1"	"0"	"1"	"0" m	
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
L	ALTITUDE METERS														
1.	Altitude "0"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	See Sheet 32 for Altitude and Altitude Rate word timing.
2.	Altitude "1"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	
3.	Altitude Rate "0"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	
4.	Altitude Rate "1"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	
5.	Altitude Meter Sync				-	-	-	-	-	-					Not Connected
M	AGS SIGNALS														
1.	Crosslink "0" Out		-	-											Not connected.
2.	Crosslink "1" Out		-	-											Not connected.
3.	Crosslink "0" In		-	-											Not connected.
4.	Crosslink "1" In		-	-											Not connected.
5.	Digital Data (AGS Initalization)	6	-	-	7±3	3±1	20	4	0.2	Digital @ 51.2	100	10(10mh)	200	20(20mh)	For digital pulse timing see sheet 32.
N	DSKY ILLUMINATION														
1.	DSKY EL Numeric Dimming	13	-	-	-	-	-	-	-	-	-	-	10K	10K	800 cps; See Sheet #25
2.	Controlled 400	13	-	-	-	-	-	-	-	-	-	-	-	-	400 cps; See Sheet #25
3.	Controlled 5 vdc	13	2-5v	-	-	-	-	-	-	-	-	-	-	-	0.180 amp/display, peak 2.5 amp. maximum (lamp test only)
4.	Controlled 5 vdc	13	2-5v	-	-	-	-	-	-	-	-	-	-	-	

INTERFACE CONTROL DOCUMENT	LGC-LEM ELECTRICAL INTERFACE	SHEET 1[illegible] OF 45	ICD NO. LIS 370-10004	REV A

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE. L. I., NEW YORK

TDRR 24050 NOV 9 1 1965

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C		PULSE						SOURCE IMPEDANCE±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP.DATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
O	LGC-DSKY INTERFACE														
1.	Key Code 1	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	These signals are included for information purposes only. The signal sources and loads, with the exception of LMP interfaces, are GFE, but GAEC provides the interconnecting cables.
2.	Key Code 2	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
3.	Key Code 3	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
4.	Key Code 4	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
5.	Key Code 5	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
6.	KYBD RST	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
7.	Standby	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
8.	ERR Light Reset	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
9.	Spare	-	28±11	0±2	-	-	-	-	-	-	>1K	Open	22K	22K	
10.	+28v. Keyboard	-	④ ②	④ ②	-	-	-	-	-	-	<1K	<1K	>4K	Open	
11.	Out 0 - 1	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
12.	Out 0 - 2	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
13.	Out 0 - 3	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
14.	Out 0 - 4	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
15.	Out 0 - 5	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
16.	Out 0 - 6	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
17.	Out 0 - 7	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
18.	Out 0 - 8	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	Also listed for LMP
19.	Out 0 - 9	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	
20.	Out 0 - 10	12*	5±2	28±11	-	-	-	-	-	-	<3K	>500K	10K	20K	* No LMP interface as listed here. See sheet 11.

INTERFACE CONTROL DOCUMENT	LGC-LEM ELECTRICAL INTERFACE	SHEET 13 OF 45	ICD NO. LIS 370-10004	REV

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP.RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
0	LGC-DSKY INTERFACE (CONT)														NOTE: * LMP Interface as listed here See Sheet 11
21.	OUT 0-11	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
22.	OUT 0-12	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	Also listed for LMP
23.	OUT 0-13	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	Also listed for LMP
24.	OUT 0-14	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	Also listed for LMP
25.	OUT 0-15	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	Also listed for LMP
26.	ISS Warning	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
27.	Comp Act.	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
28.	STDBY Lamp	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
29.	Restart	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
30.	RR Enable	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
31.	LR POS CMD	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
32.	Uplink ACT	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
33.	Key Release	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
34.	LGC Warning	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
35.	VERB/NOUN Flash	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
36.	OP Error (Flash)	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
37.	Power sync.	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
38.	TEMP Caution	12*	5±2	28±11	-	-	-	-	-	-	< 3K	> 500K	10K	20K	
39.	SPARE 2		-	-	-	-	-	-	-	-	-	-	-	-	Not Connected
40.	SPARE 3		-	-	-	-	-	-	-	-	-	-	-	-	Not Connected
41.	DSKY GND	-	-	-	-	-	-	-	-	-	-	-	-	-	Interfaces LMP (Ckt-12)
42.	Spare	-	-	-	-	-	-	-	-	-	-	-	-	-	
43.	+14v. (Switched)	-	-	-	-	-	-	-	-	-	-	-	-	-	Interfaces LMP (Ckt-12)
44.	+28v.	-	-	-	-	-	-	-	-	-	-	-	-	-	

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP.RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
P	LGC POWER INPUTS														
1.	Bus A HI	14	-	-	-	-	-	-	-	-	④ ①	④ ①	④ ②	④ ②	See Sheet No. 28
2.	Bus A LOW	14	-	-	-	-	-	-	-	-	④ ①	④ ①	④ ②	④ ②	Input circuitry included for information only. This interface is controlled by ICD#390-10002.

SECTION II

TDRR 24050

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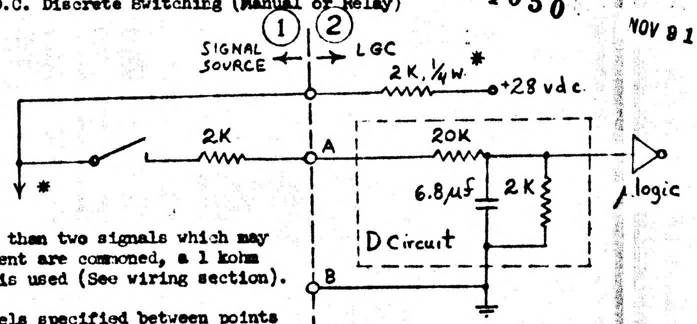
Circuit 1: D.C. Discrete Switching (Manual or Relay)


①
②
SIGNAL SOURCE
LGC
2K, 1/4W *
+28 vdc
2K
A
20K
6.8μf
2K
D Circuit
logic
B
*

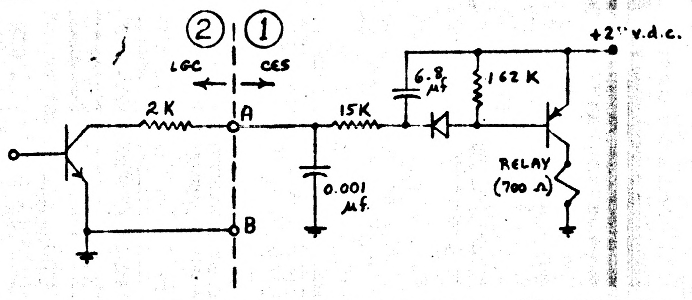
*Where more than two signals which may be coincident are commoned, a 1 kohm isolation is used (See wiring section).

Signal levels specified between points A and B at interface, with point B at the reference level.

Noise Limits:

1. Switch closed ("1"): Maximum noise amplitude -50v., if noise pulse does not exceed 0.5 millisecond width at maximum repetition rate of 50 pps.
2. Switch open ("0"): Maximum noise amplitude +50V., if noise pulse does not exceed 1 millisecond width at maximum repetition rate of 50 pps.

Circuit 2 A: Engine On and Engine Off Discretes


②
①
LGC
CES
+2" v.d.c.
2K
A
15K
6.8 μf
162 K
0.001 μf
RELAY (700 Ω)
B

Signal levels specified between points A and B at interface, with point B the reference level.

Noise Limits: As specified for Circuit 1, above.

SECTION II:

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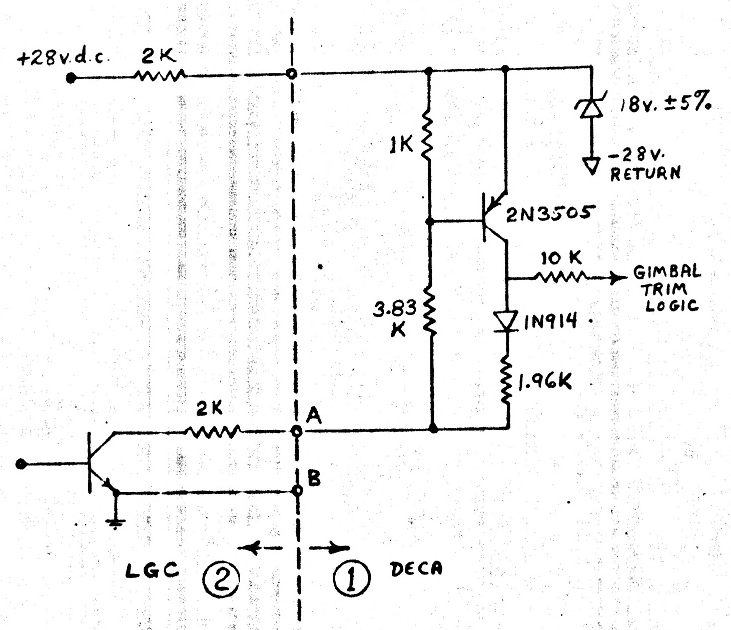
Circuit 2 B: Gimbal Trim Commands

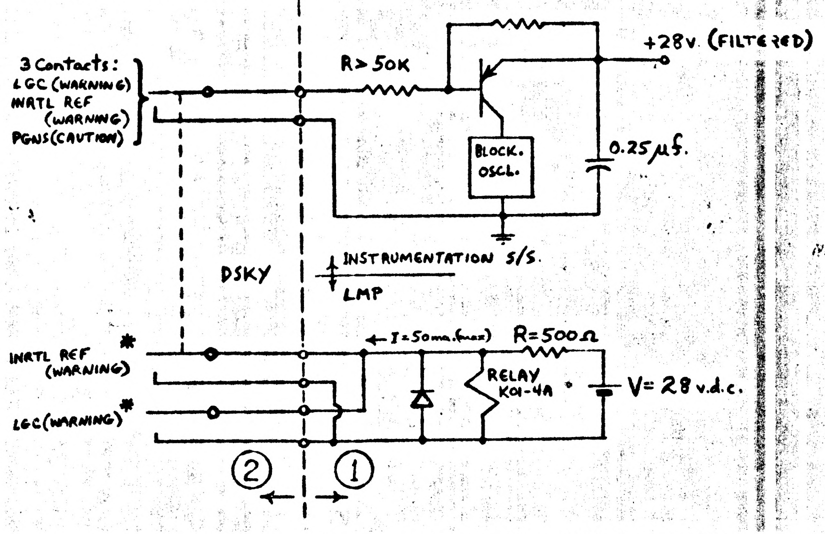

+28v.d.c.
2K
18v. ±5%
-28v. RETURN
1K
2N3505
10 K
GIMBAL TRIM LOGIC
3.83 K
1N914
1.96K
2K
A
B
LGC
②
①
DECA

Signal levels specified between points A and B at interface, with point B the reference level.

Noise limits as specified in Circuit 1, above.

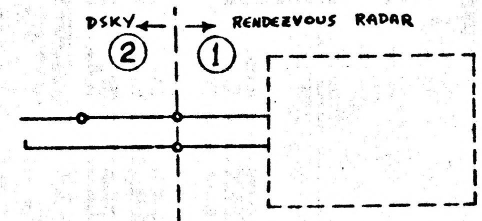
SECTION II:

Circuit 3A: Caution and Warning Discretes


3 Contacts:
LGC (WARNING)
INRTL REF (WARNING)
PGNS (CAUTION)
R > 50K
+28v. (FILTERED)
BLOCK. OSCL.
0.25μf.
DSKY
INSTRUMENTATION S/S.
LMP
INRTL REF (WARNING) *
LGC (WARNING) *
← I = 50ma. (max)
R = 500Ω
RELAY K01-4A
V = 28 v.d.c.
②
①

*Second contact, required for "INRTL REF (Warning)" and "LGC (Warning)", connected in the unmanned configuration.

Circuit 3B: Auto Angle Track Enable Discrete


DSKY
②
RENDEZVOUS RADAR
①

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Relay Type: ④ ②

Switch will be closed to indicate signal present. Maximum switch current; 1/2 amp.

SECTION II

Circuit 3C: Antenna Position Command

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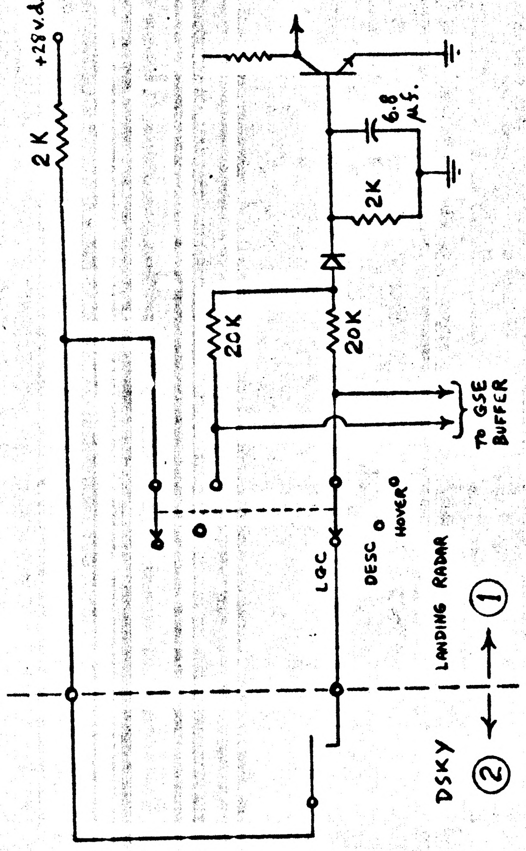
+28v.d.c.
2 K
6.8 μf.
2K
20K
20K
To GSE BUFFER
LGC
DESC
HOVER
LANDING RADAR
DSKY
②
①

Switch will be closed to indicate signal present. Maximum switch current; 1/2 amp.

SECTION II

Circuit 4: Attitude Hand Controller

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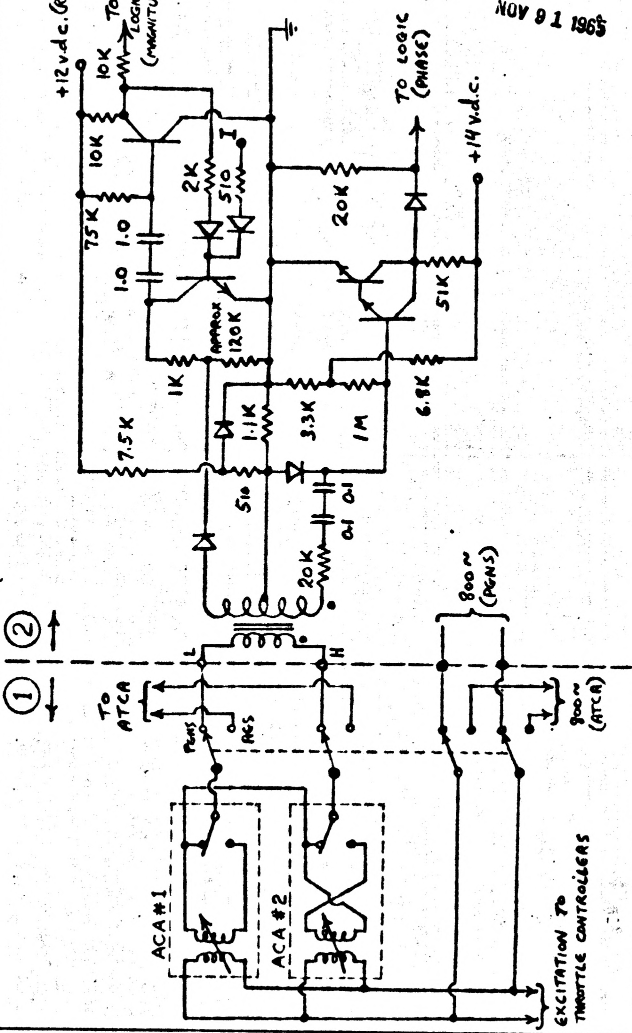

+12 v.d.c. (REG.)
10K
TO LOGIC (MAGNITUDE)
10K
75K
1.0
1.0
2K
510
I
APPROX 120K
1K
7.5K
1.1K
510
3.3K
1M
0.1
0.1
20K
20K
51K
6.8K
TO LOGIC (PHASE)
+14 v.d.c.
①
②
To ATCA
L
H
PGNS
AGS
ACA #1
ACA #2
800~ (PGNS)
800~ (ATCA)
EXCITATION TO THROTTLE CONTROLLERS

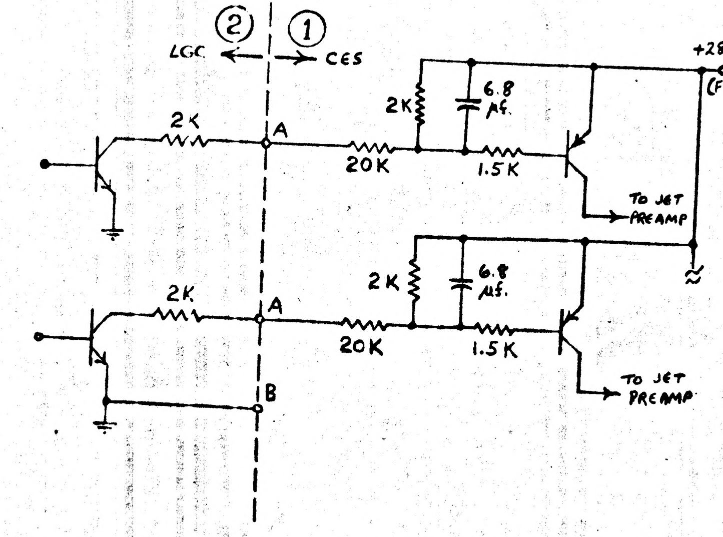
A Circuit:

Linearity ± 10%., 1/2° < θ < 11°
Quantization - 32 states / 11°
Load impedance, non-linear 2-20 K ohms.
[illegible] 20 [illegible] when reading
Sample rate, 5-8 per second.

Out of Detent indication 3/4°±1/4° Null Voltage 30 mv. RMS max., load 10K ohm. Quadrature 10 mv RMS max., load 10 ohm. Scale factor 2.8 volts ± 0.14 volts RMS at 11° hand controller position, load 10 Kohm. Source impedance 2K at 85°. Rate Command 7.15 degrees/sec - volt RMS. Ann ... excitation (PGNS 800 cps.) Phase shift 0-10° maximum into 10K ohm load. In-phase output corresponds to positive rate command. Linearity 5%.

SECTION II

Circuit 5: RCS Jet Discretes


②
①
LGC
CES
2K
A
20K
2K
6.8 µf.
1.5K
+28 v.d c. (FILTERED)
To JET PREAMP
2K
A
20K
2K
6.8 µf.
1.5K
To JET PREAMP
B

16 .Drive Signals use similar circuits with common 28 v. (filtered) source.

All measurements made between points A and B; B Reference.

Amplitude "1"; source impedance less than 3K, I_c = 5 ma. maximum

Amplitude "0"; source impedance greater than 500K, V = 40 vdc. maximum.

Noise Limits

Same as for Circuit 1, above.

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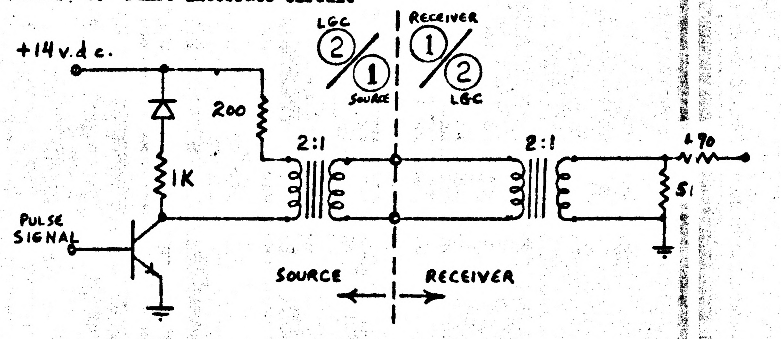
SECTION II

Circuit 6: Pulse Interface Circuit


+14 v.d c.
200
1K
PULSE SIGNAL
2:1
LGC
②
①
SOURCE
RECEIVER
①
②
LGC
2:1
470
51
SOURCE
RECEIVER

Transformers specified by NASA drawing #1006319.

Presence of pulse (s) shall indicate "on" ("1") condition.

Absence of Pulse (s) shall indicate "off" ("0") condition.

Noise Limits:

1. During the "on" condition, the signal plus noise shall remain within the envelope defined by the parameters for the interface signal given in Section I.
2. During the "off" condition, the noise shall remain within the envelope defined by the upper limit of +0.4v., and lower-limit -4.0v., measured with respect to the Amplitude Reference level.

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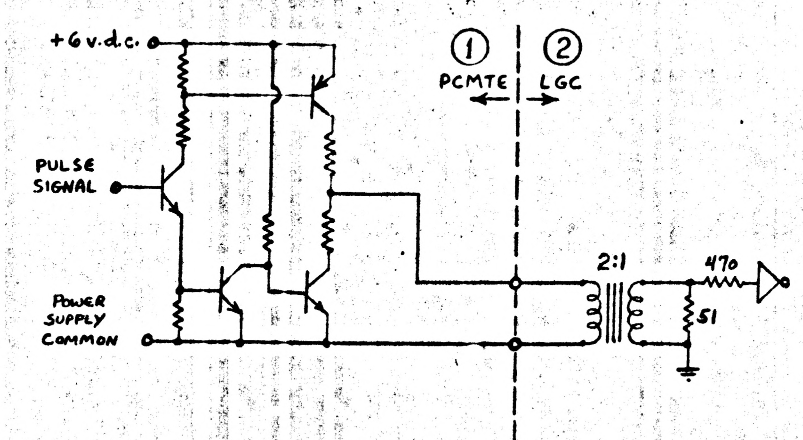
SECTION II

Circuit 7: PCMTE Outputs


+6 v.d.c.
①
②
PCMTE
LGC
PULSE SIGNAL
POWER SUPPLY COMMON
2:1
470
51

Transformer specified by NASA drawing #1006319

For tolerable noise limits, see notes of circuit 6.

Levels specified on signal listing measured at PCMTE with 200 Ω resistive load.

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SECTION II

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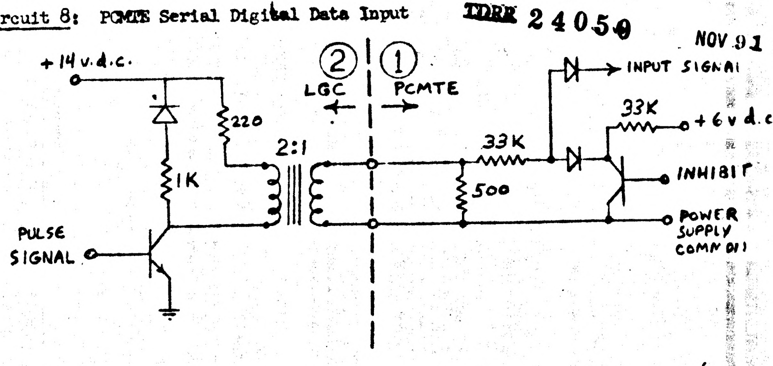
Circuit 8: PCMTE Serial Digital Data Input

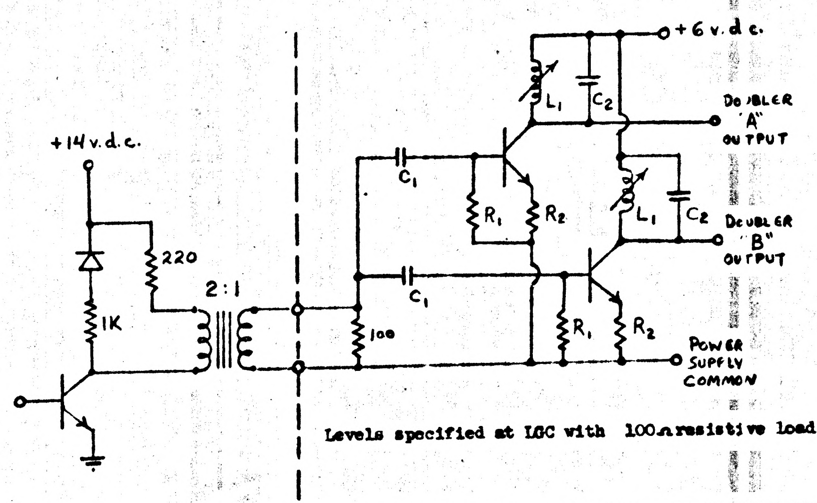

+14 v.d.c.
220
1K
PULSE SIGNAL
2:1
②
①
LGC
PCMTE
500
33K
33K
INPUT SIGNAL
+6 v.d.c.
INHIBIT
POWER SUPPLY COMMON

Transformer specified by NASA drawing #1006319

Levels specified at LGC with 500 Ω resistive load.

For tolerable noise limits, see notes of circuit 6.

Circuit 9: PCMTE 1024 kc. Sync Signal Input


+14 v.d.c.
220
1K
2:1
100
C1
C1
R1
R2
R1
R2
L1
C2
L1
C2
+6 v.d.c.
DOUBLER "A" OUTPUT
DOUBLER "B" OUTPUT
POWER SUPPLY COMMON

Levels specified at LGC with 100 Ω resistive load.

SECTION II

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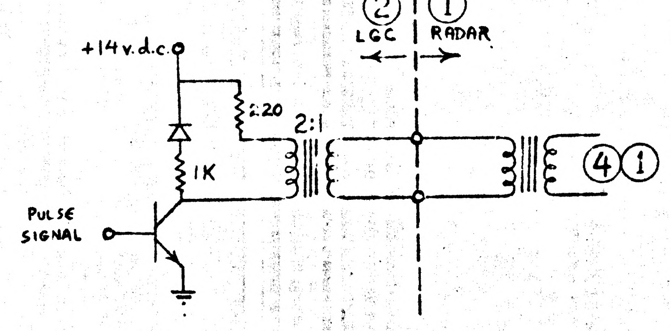
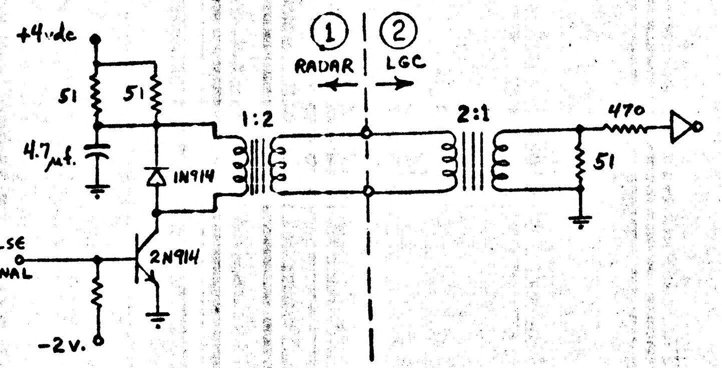
Circuit 10: Radar Pulse Inputs


+14 v.d.c.
1:20
1K
PULSE SIGNAL
2:1
②
①
LGC
RADAR
④①

Transformers specified by NASA drawing #1006319

For tolerable noise limits, see notes of circuit 6.

Circuit 11: Radar Pulse Outputs


+4 v.dc
51
51
4.7 µf.
1N914
2N914
PULSE SIGNAL
-2v.
1:2
①
②
RADAR
LGC
2:1
470
51

Transformers specified by NASA drawing #1006319

For tolerable noise limits, see notes of circuit 6.

SECTION II

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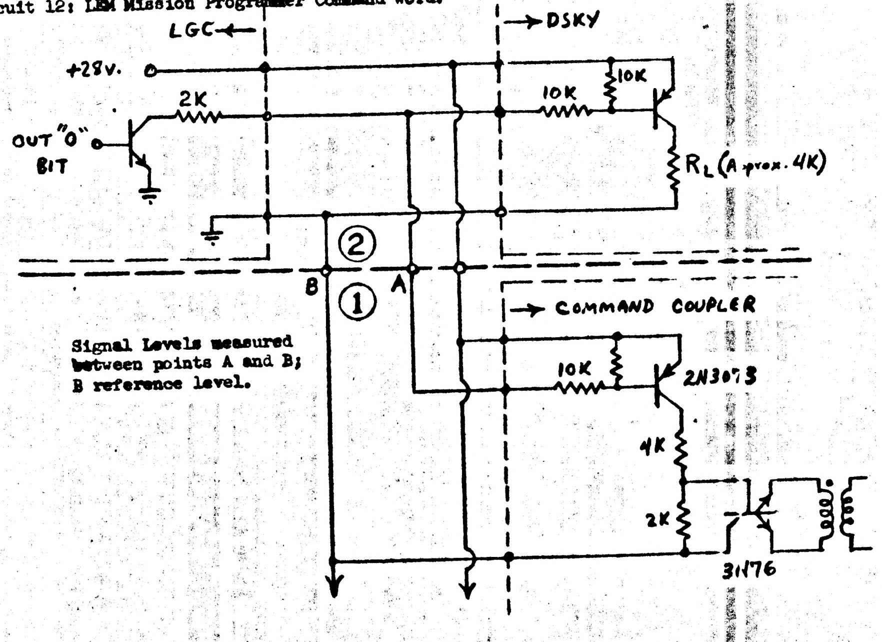
Circuit 12: LEM Mission Programmer Command Word.


LGC
+28v.
2K
OUT "0" BIT
②
①
B
A
DSKY
10K
10K
RL (Aprox. 4K)
COMMAND COUPLER
10K
2N3013
4K
2K
31176

Signal Levels measured between points A and B; B reference level.

LGC ground may not be tied to Command Coupler ground.

LGC +28 volts may not be connected except as shown.

Circuit 12*, referenced for LGC-DSKY wiring, is as shown above, but with no command coupler interface.

SECTION II

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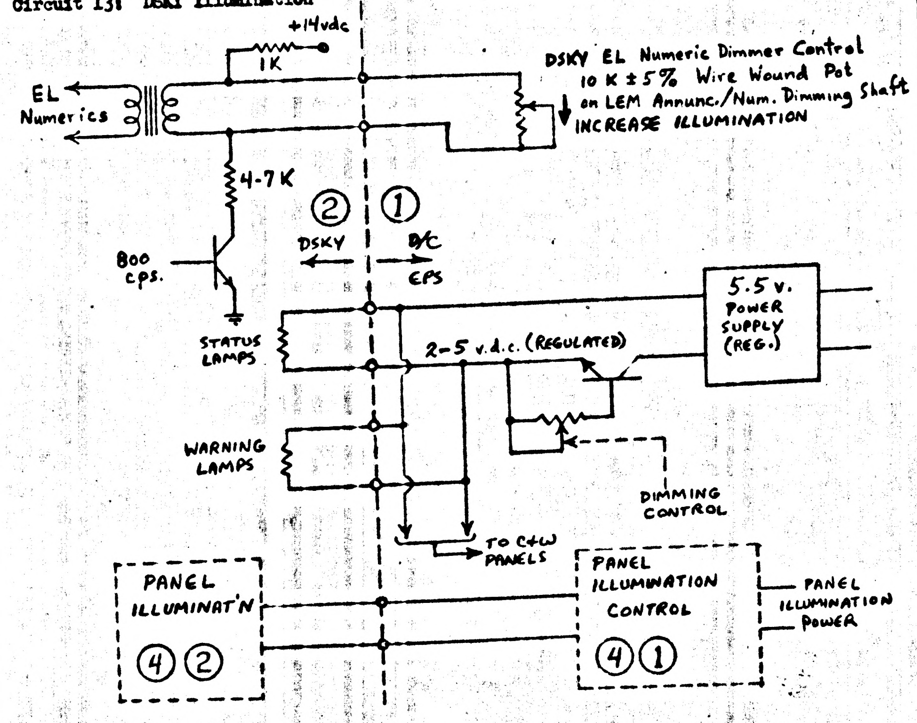
Circuit 13: DSKY Illumination


+14vdc
1K
EL Numerics
DSKY EL Numeric Dimmer Control 10 K ± 5% Wire Wound Pot on LEM Annunc./Num. Dimming Shaft
INCREASE ILLUMINATION
4.7K
800 cps.
②
①
DSKY
B/C
EPS
STATUS LAMPS
WARNING LAMPS
2-5 v.d.c. (REGULATED)
5.5 v. POWER SUPPLY (REG.)
DIMMING CONTROL
TO C&W PANELS
PANEL ILLUMINAT'N
④②
PANEL ILLUMINATION CONTROL
④①
PANEL ILLUMINATION POWER

Panel Illumination Power

Voltage 115v. ± 2.5v. (controlled 20-75 volts. Emergency condition 115v.).

Current 17.5ma. (input power not to exceed 0.66 watts at 75v.).

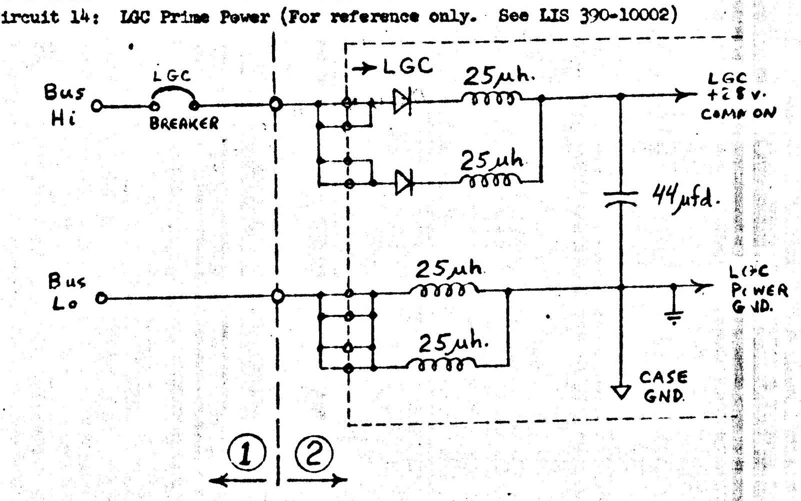
Noise: Modulation per MIL STD 704

Transient voltages shall not exceed 225 volts, peak, from transient start to 2.5 millisecond. After 2.5 millisecond the voltage shall be within the limits of 144 volts, peak to 188 volts, peak with recovery to steady-state conditions within 50 milliseconds.

Voltage spikes, superimposed on a.c., of 10v. max. amplitude with 90% recovery time within 250 sec.

SECTION II

Circuit 14: LGC Prime Power (For reference only. See LIS 390-10002)


Bus Hi
LGC
BREAKER
→LGC
25μh.
25μh
LGC +28v. COMMON
44μfd.
Bus Lo
25μh.
25μh.
LGC POWER GND.
CASE GND
①
②

Prime Power Characteristics

(For reference only. See LIS 390-10002)

Voltage: ④ ①

Current: 4 amps max.

Standby Current: 0.5 amp

Circuits

Diodes specified in NASA Dwg # 1006329

Inductance specified in NASA Dwg # 1006327

BKR. ④ ①

C greater than 40 microfarad

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SECTION III-1 TDRR 24050 NOV 9 1 1965

WAVEFORM DESCRIPTION

Pulse waveform nomenclature used in the tables of section I is defined below:

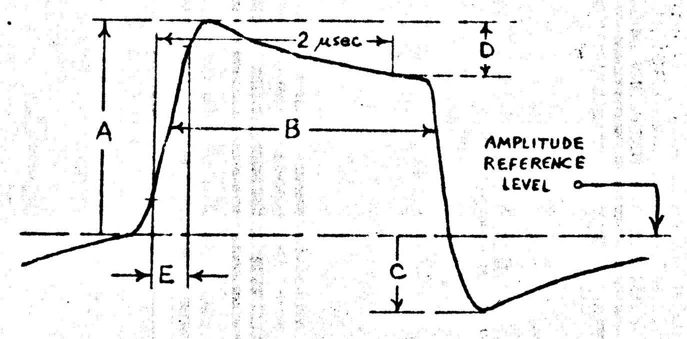

2 μsec
D
A
B
AMPLITUDE REFERENCE LEVEL
E
C

Figure 1

A. Amplitude-measured to pulse maximum positive level.

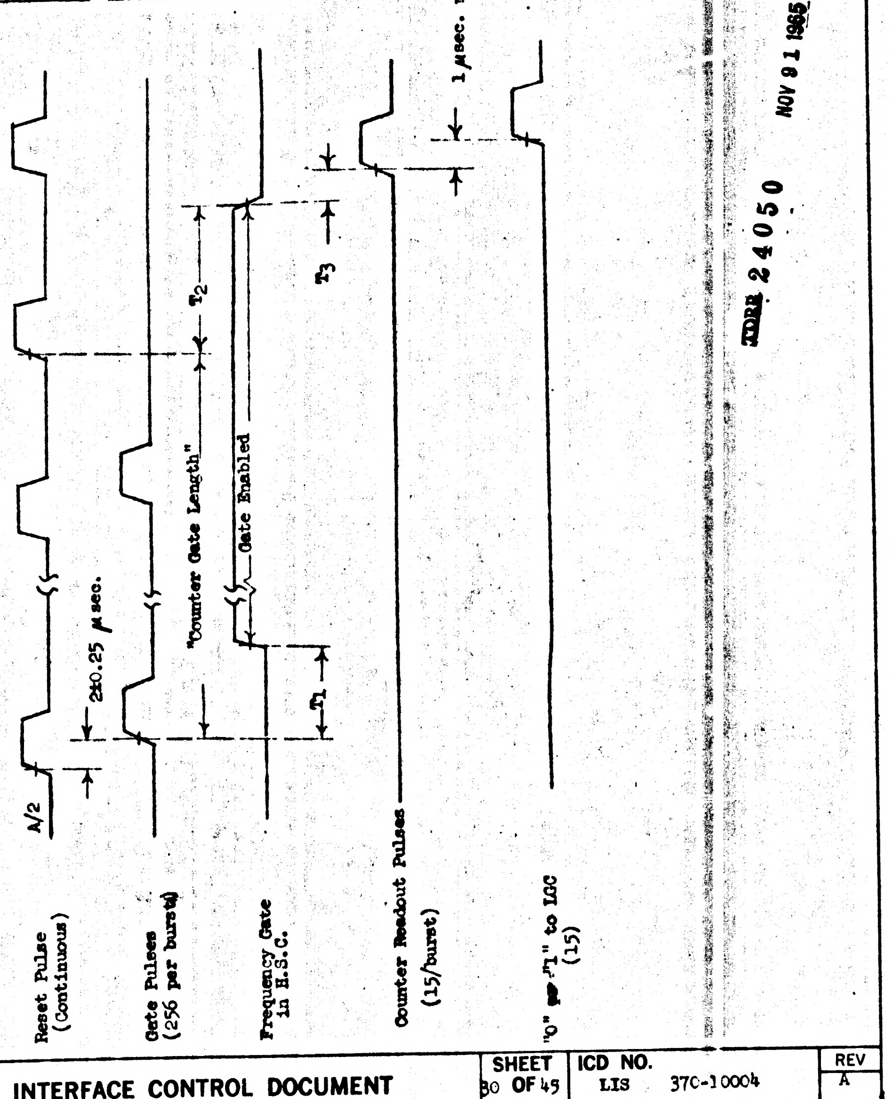
B. Pulse width-measured at A/2 level.

C. Backswing-measured to signal maximum negative level.

D. Droop-measured from pulse maximum positive level to level at 2 μsec.

E. Rise Time-time required for pulse to rise from 10% to 90% of A.

SECTION III-2 RADAR PULSE TIMING:


Reset Pulse (Continuous)
A/2
240.25 μsec.
Gate Pulses (256 per burst)
"Counter Gate Length"
T_2
Frequency Gate in H.S.C.
Gate Enabled
T_1
T_3
Counter Readout Pulses (15/burst)
1 μsec. max.
"0" or "1" to LGC (15)

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Radar Pulse Timing (Continued):

A. Maximum delay of 1 usec. between Counter Readout and Data Pulse (see figure above).

B. The 15 Counter Readout pulses will generate 15 "0" or "1" pulses. The more significant bit will occur earlier in time. A "1" is represented as a pulse on the "1" line and a "0", as the presence of a pulse on the "0" line.

C. Delay between the first gate pulse and opening of frequency gate:

Rendezvous Radar: T_1 = 313.5 ± 0.75 usec.
Landing Radar: T_1 = Approx. 0.1 usec.

D. Delay between reset pulse and closing of frequency counter gate:

Rendezvous Radar: T_2 = 315.5 ± 0.5 usec.
Landing Radar: T_2 = 3.1 ± 0.5 usec.

E. Gate Closure to CRO Pulse:

Rendezvous Radar: T_3 = 309.5 ± 0.5 usec (Minimum Value)
Counter is reset, and may be strobed again at end of T_3.

Landing Radar: T_3 = 2 usec. (Minimum value) Counter is reset, and may be strobed again, 312.5 usec. after end of Counter Gate.

F. Counter Gate Length:

Rendezvous Radar: 79998.0 ± 0.25 usec.

Landing Radar: 79998.0 ± 0.25 usec.

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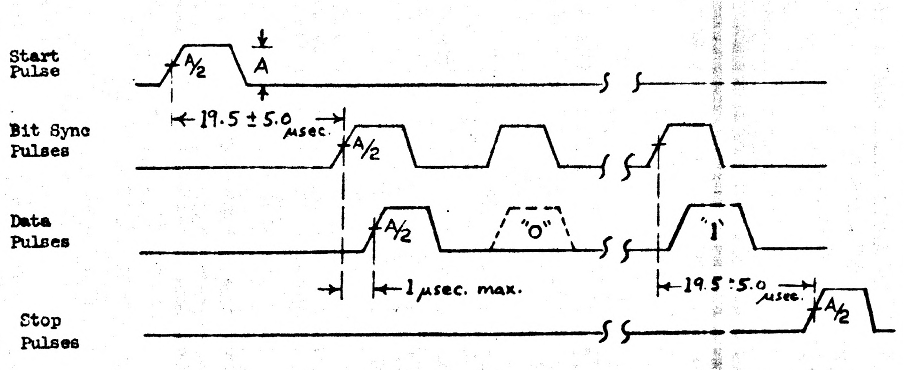
SECTION III-3

Down Link Timing


Start Pulse
A/2
A
19.5 ± 5.0 μsec.
Bit Sync Pulses
A/2
Data Pulses
A/2
"0"
"1"
1 μsec. max.
19.5 ± 5.0 μsec.
Stop Pulses
A/2

a. Start pulses: rate 50 pps.

b. Bit sync pulses: Rate 51.2 pps. There will be 40 pulses between each start and stop pulse,

c. Data Pulses: Frequency and width determined by bit sync pulses. A "1" is the presence of a pulse and a zero as the absence of a pulse with a bit sync pulse.

d. Stop pulses: Rate 50 pps.

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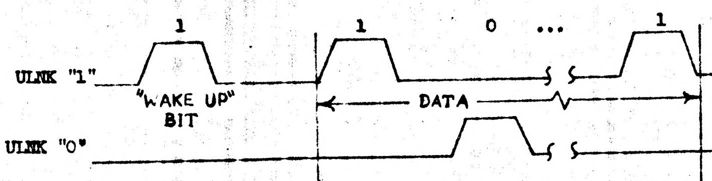
SECTION III-4

Uplink Timing


1
1
0
...
1
ULNK "1"
"WAKE UP" BIT
DATA
ULNK "0"

a. Bit rate of 0's and I's is 1.1 Kpps maximum.

b. 1 word is composed of 16 pulses; a "wake up" on the "I" line followed by 15 bits on the "I" or "0" lines.

c. Minimum time between words is 0.1 seconds.

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SECTION III-5

Altitude Output

1. The signal will be a 16 bit (15 data bits) whole number transfer. The number will be shifted out at a 3.2K pps rate on two lines.
2. The first pulse shall always be a "I" and will be on "wake up" pulse (not data). The next 15 pulses will occur in the "I" or "0" lines depending as to whether the data in that bit position will be a "I" or a "0".
3. High order bits are shifted out first.
4. Quantization - 2.3450 feet equals least significant bit.
5. Data will be updated five times per second.

Altitude Rate Output

1. Same as (1) above.
2. Same as (2) above.
3. Same as (3) above.
4. Quantization 1/2 ft/sec equals least significant bit.
5. Same as (5) above.
6. Sign will be determined by bit 15 (follows wake up bit); altitude is increasing when sign bit is a "0". Bits 1-14 represent magnitude of number to be displayed.

SECTION IV

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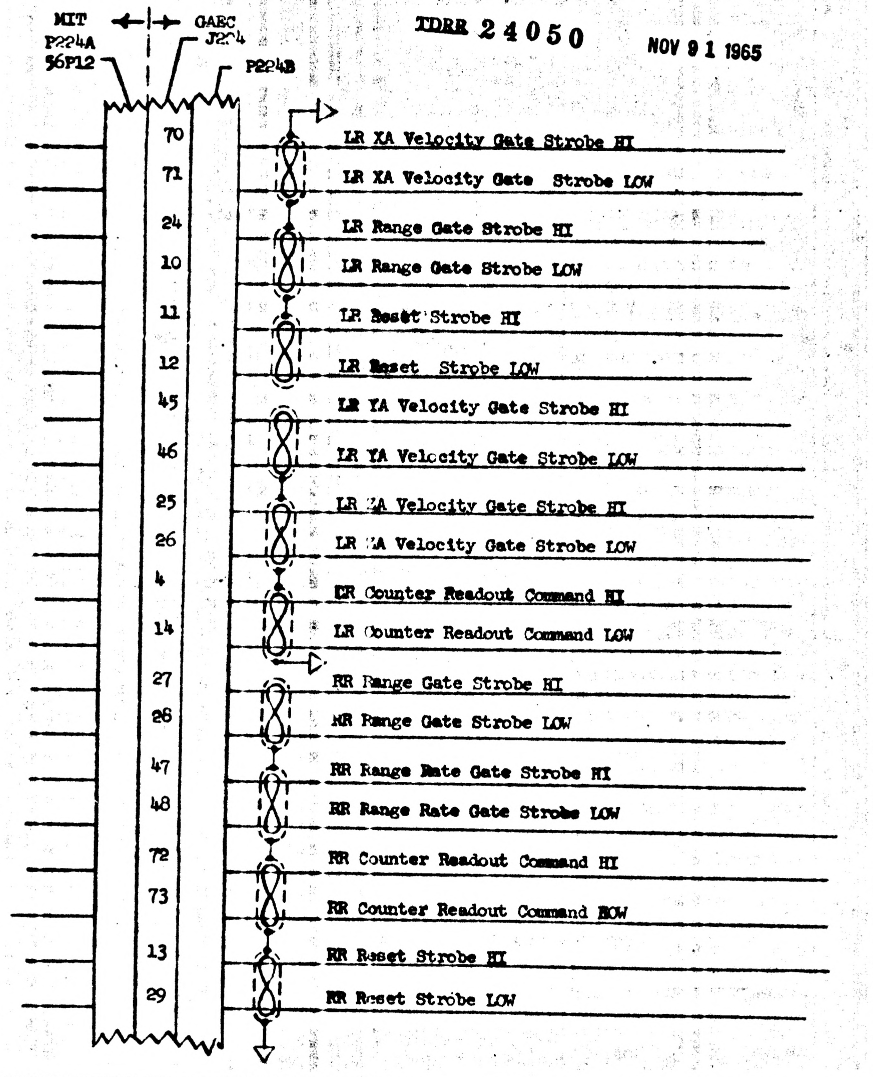
MIT
P224A
56P12
GAEC
J224
P224B
70
71
24
10
11
12
45
46
25
26
4
14
27
28
47
48
72
73
13
29
LR XA Velocity Gate Strobe HI
LR XA Velocity Gate Strobe LOW
LR Range Gate Strobe HI
LR Range Gate Strobe LOW
LR Reset Strobe HI
LR Reset Strobe LOW
LR YA Velocity Gate Strobe HI
LR YA Velocity Gate Strobe LOW
LR ZA Velocity Gate Strobe HI
LR ZA Velocity Gate Strobe LOW
LR Counter Readout Command HI
LR Counter Readout Command LOW
RR Range Gate Strobe HI
RR Range Gate Strobe LOW
RR Range Rate Gate Strobe HI
RR Range Rate Gate Strobe LOW
RR Counter Readout Command HI
RR Counter Readout Command LOW
RR Reset Strobe HI
RR Reset Strobe LOW

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SECTION: IV

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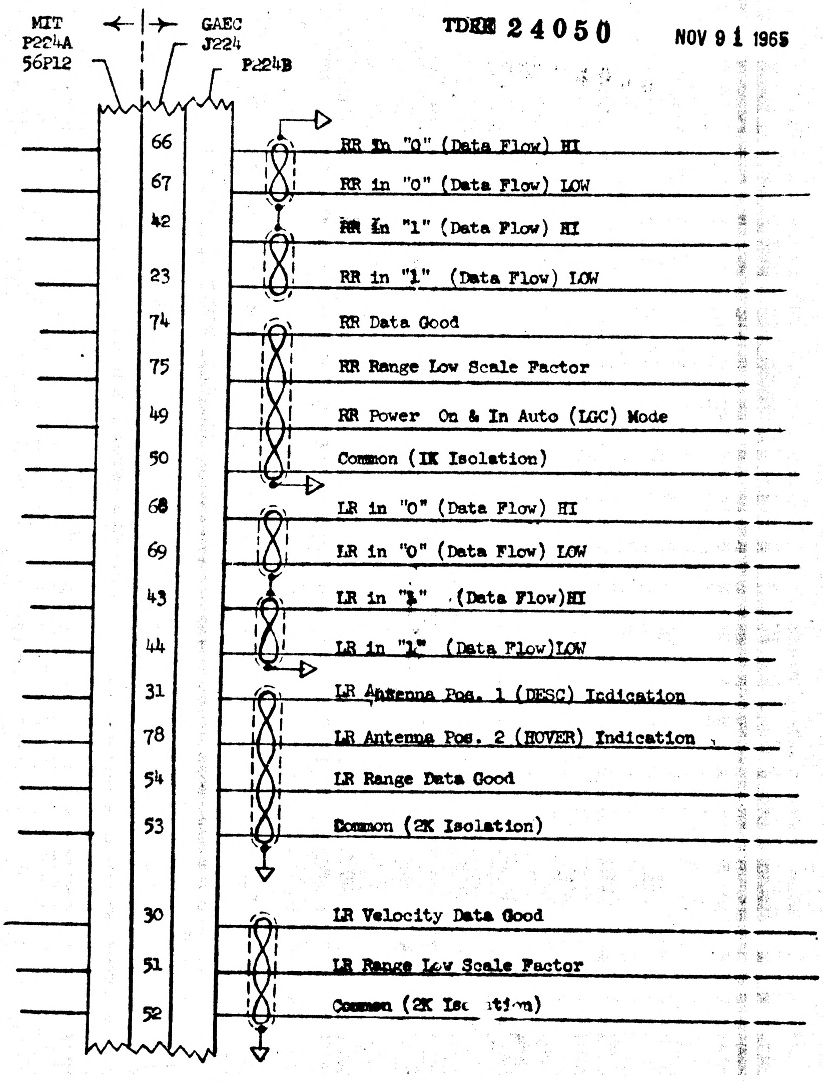

Pin	Signal
66	RR In "0" (Data Flow) HI
67	RR in "0" (Data Flow) LOW
42	RR In "1" (Data Flow) HI
23	RR in "1" (Data Flow) LOW
74	RR Data Good
75	RR Range Low Scale Factor
49	RR Power On & In Auto (LGC) Mode
50	Common (1K Isolation)
68	LR in "0" (Data Flow) HI
69	LR in "0" (Data Flow) LOW
43	LR in "1" (Data Flow) HI
44	LR in "1" (Data Flow) LOW
31	LR Antenna Pos. 1 (DESC) Indication
78	LR Antenna Pos. 2 (HOVER) Indication
54	LR Range Data Good
53	Common (2K Isolation)
30	LR Velocity Data Good
51	LR Range Low Scale Factor
52	Common (2K Isolation)

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SECTION IV:

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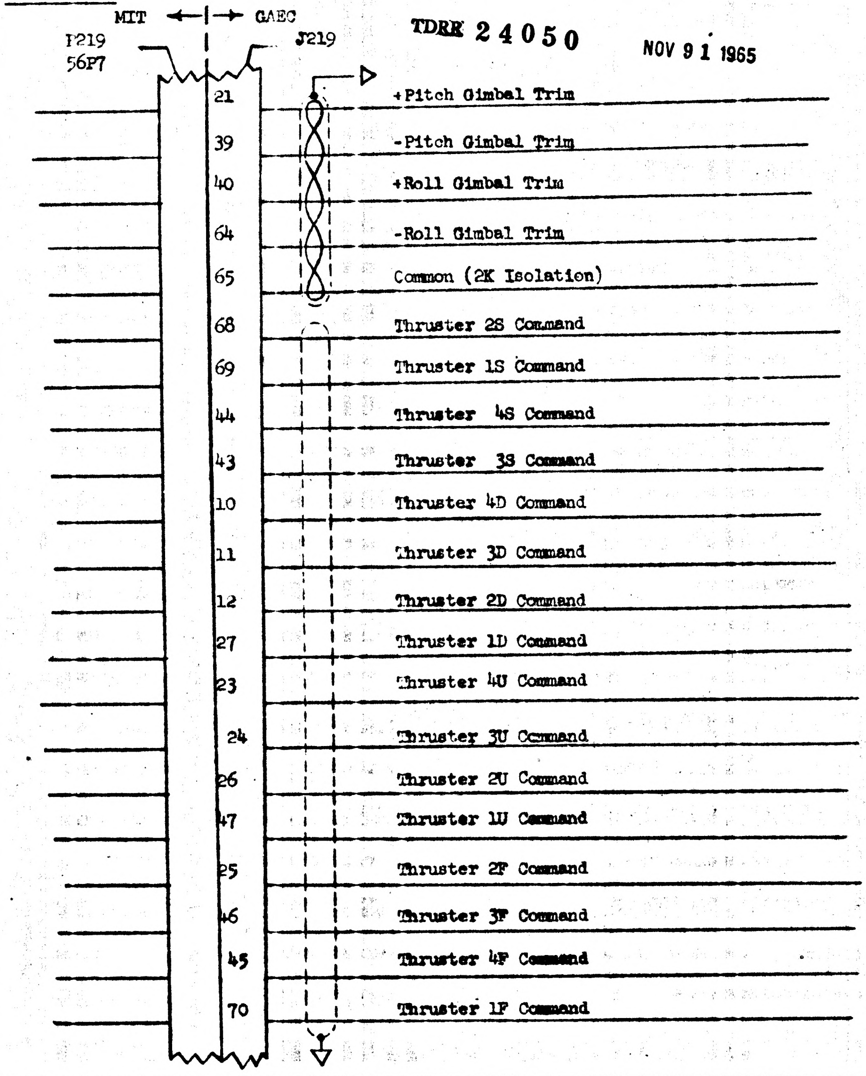

Pin	Signal
21	+Pitch Gimbal Trim
39	-Pitch Gimbal Trim
40	+Roll Gimbal Trim
64	-Roll Gimbal Trim
65	Common (2K Isolation)
68	Thruster 2S Command
69	Thruster 1S Command
44	Thruster 4S Command
43	Thruster 3S Command
10	Thruster 4D Command
11	Thruster 3D Command
12	Thruster 2D Command
27	Thruster 1D Command
23	Thruster 4U Command
24	Thruster 3U Command
26	Thruster 2U Command
47	Thruster 1U Command
25	Thruster 2F Command
46	Thruster 3F Command
45	Thruster 4F Command
70	Thruster 1F Command

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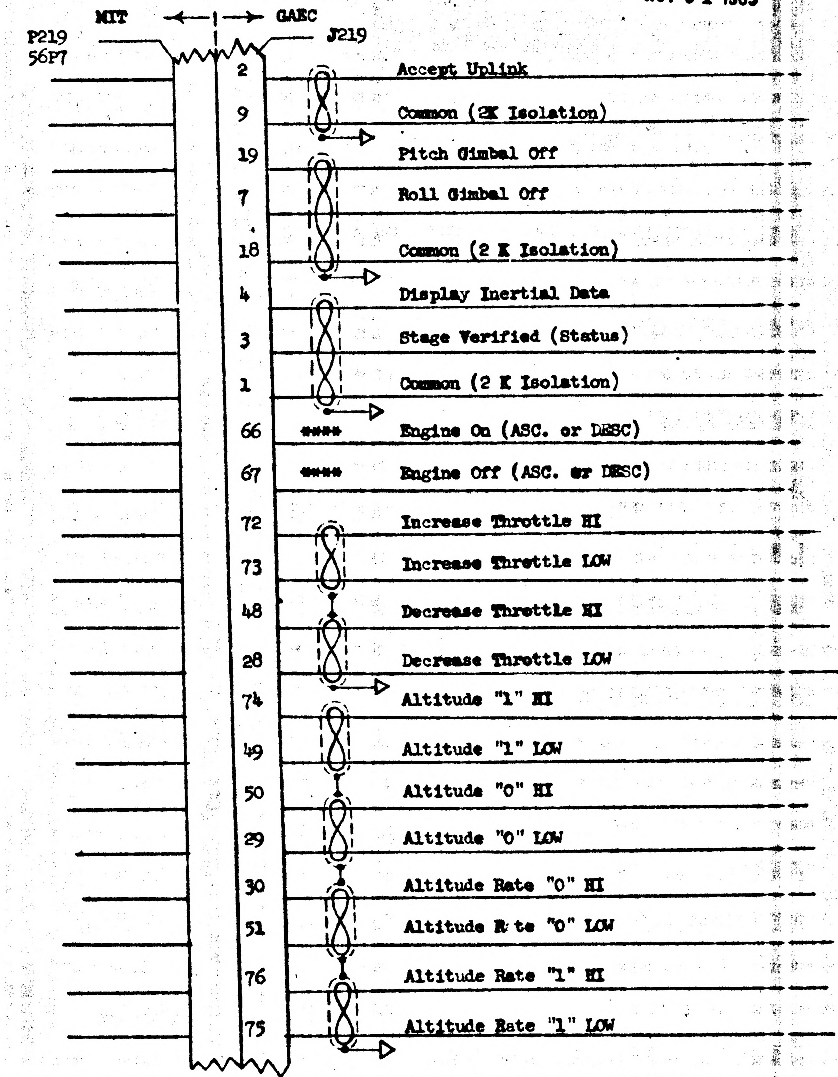

Pin	Signal
2	Accept Uplink
9	Common (2K Isolation)
19	Pitch Gimbal Off
7	Roll Gimbal Off
18	Common (2 K Isolation)
4	Display Inertial Data
3	Stage Verified (Status)
1	Common (2 K Isolation)
66	**** Engine On (ASC. or DESC)
67	**** Engine Off (ASC. or DESC)
72	Increase Throttle HI
73	Increase Throttle LOW
48	Decrease Throttle HI
28	Decrease Throttle LOW
74	Altitude "1" HI
49	Altitude "1" LOW
50	Altitude "0" HI
29	Altitude "0" LOW
30	Altitude Rate "0" HI
51	Altitude Rate "0" LOW
76	Altitude Rate "1" HI
75	Altitude Rate "1" LOW

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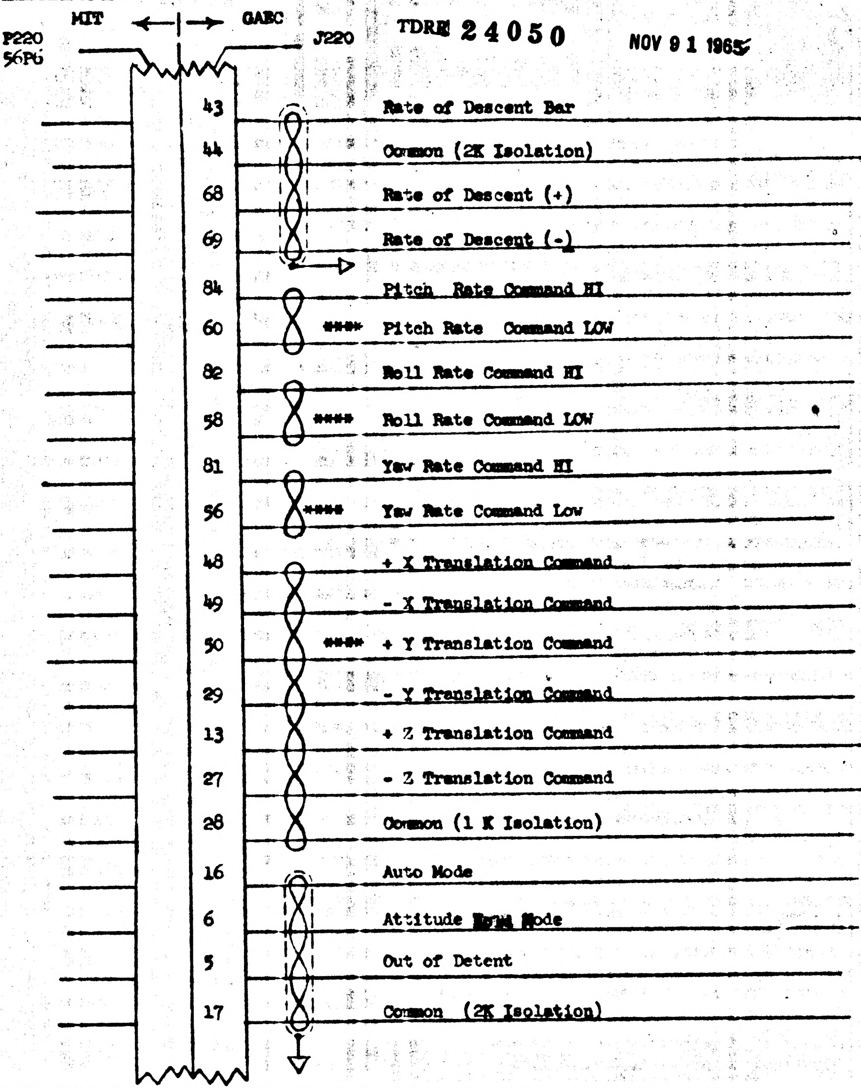

Pin	Signal
43	Rate of Descent Bar
44	Common (2K Isolation)
68	Rate of Descent (+)
69	Rate of Descent (-)
84	Pitch Rate Command HI
60	**** Pitch Rate Command LOW
82	Roll Rate Command HI
58	**** Roll Rate Command LOW
81	Yaw Rate Command HI
56	**** Yaw Rate Command Low
48	+ X Translation Command
49	- X Translation Command
50	**** + Y Translation Command
29	- Y Translation Command
13	+ Z Translation Command
27	- Z Translation Command
28	Common (1 K Isolation)
16	Auto Mode
6	Attitude [illegible] Mode
5	Out of Detent
17	Common (2K Isolation)

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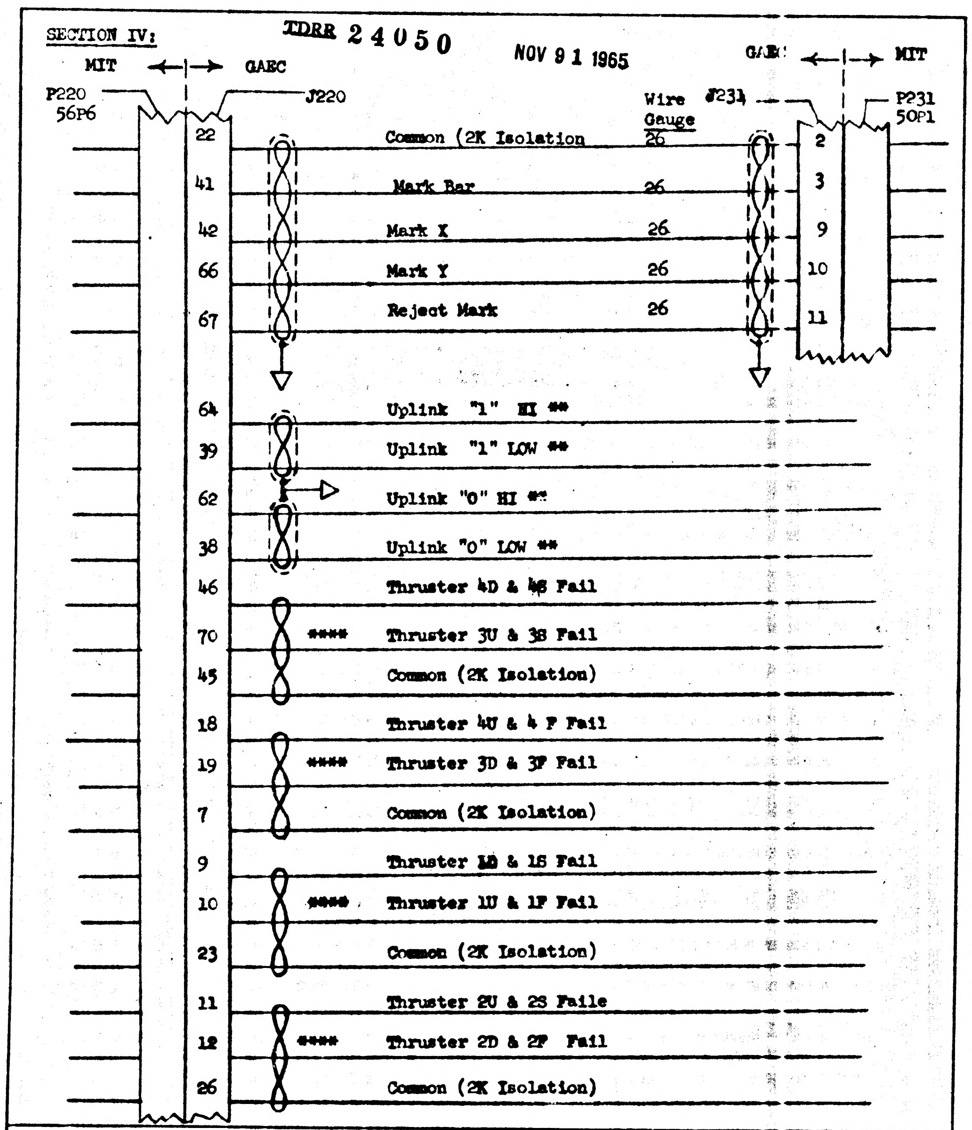

J220		Wire Gauge	P231
22	Common (2K Isolation	26	2
41	Mark Bar	26	3
42	Mark X	26	9
66	Mark Y	26	10
67	Reject Mark	26	11
64	Uplink "1" HI **		
39	Uplink "1" LOW **		
62	Uplink "0" HI **		
38	Uplink "0" LOW **		
46	Thruster 4D & 4S Fail		
70	**** Thruster 3U & 3S Fail		
45	Common (2K Isolation)		
18	Thruster 4U & 4 F Fail		
19	**** Thruster 3D & 3F Fail		
7	Common (2K Isolation)		
9	Thruster 1D & 1S Fail		
10	**** Thruster 1U & 1F Fail		
23	Common (2K Isolation)		
11	Thruster 2U & 2S Faile		
12	**** Thruster 2D & 2F Fail		
26	Common (2K Isolation)		

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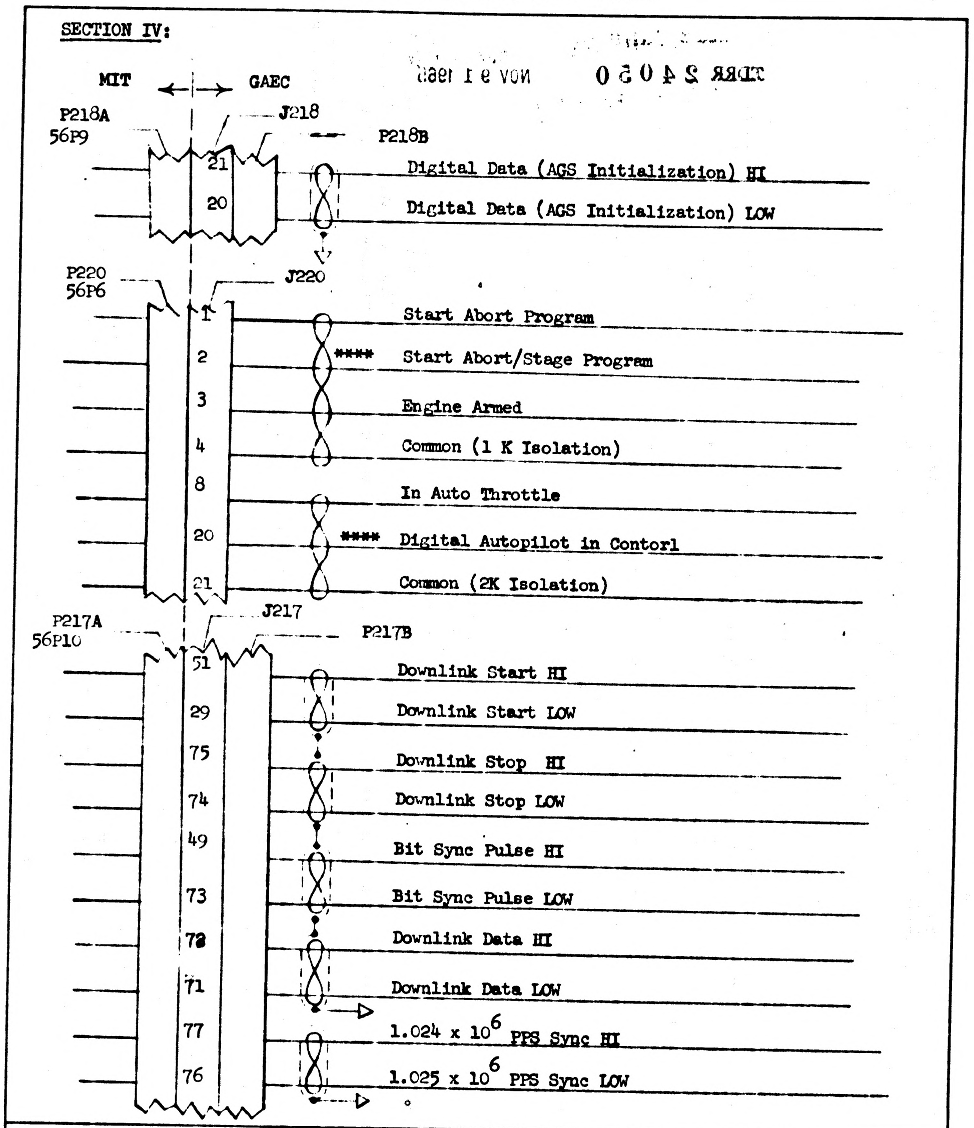

J218	
21	Digital Data (AGS Initialization) HI
20	Digital Data (AGS Initialization) LOW

J220	
1	Start Abort Program
2	**** Start Abort/Stage Program
3	Engine Armed
4	Common (1 K Isolation)
8	In Auto Throttle
20	**** Digital Autopilot in Contorl
21	Common (2K Isolation)

J217	
51	Downlink Start HI
29	Downlink Start LOW
75	Downlink Stop HI
74	Downlink Stop LOW
49	Bit Sync Pulse HI
73	Bit Sync Pulse LOW
72	Downlink Data HI
71	Downlink Data LOW
77	1.024 x 10^6 PPS Sync HI
76	1.025 x 10^6 PPS Sync LOW

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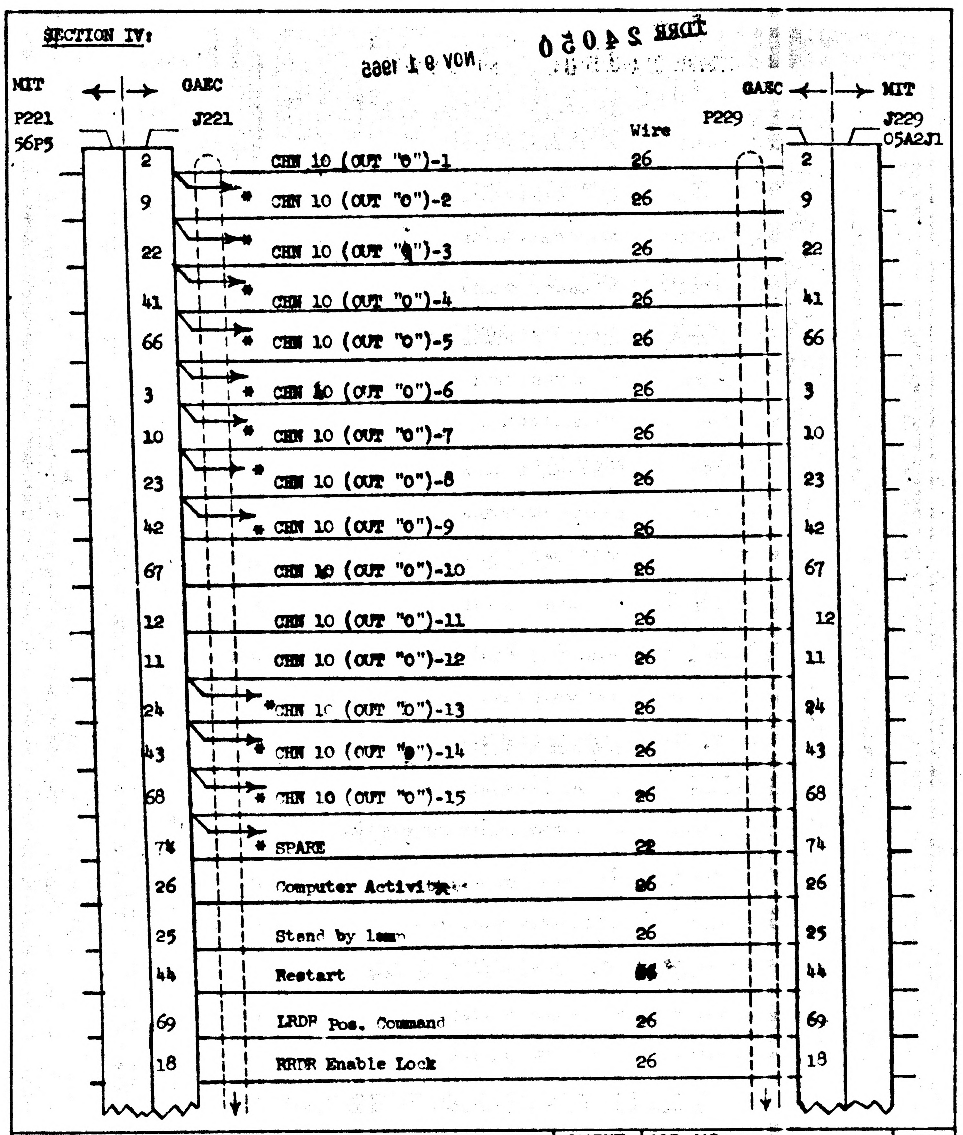
INTERFACE CONTROL DOCUMENT	41 OF 45	LIS 370-10004	A

SECTION IV:

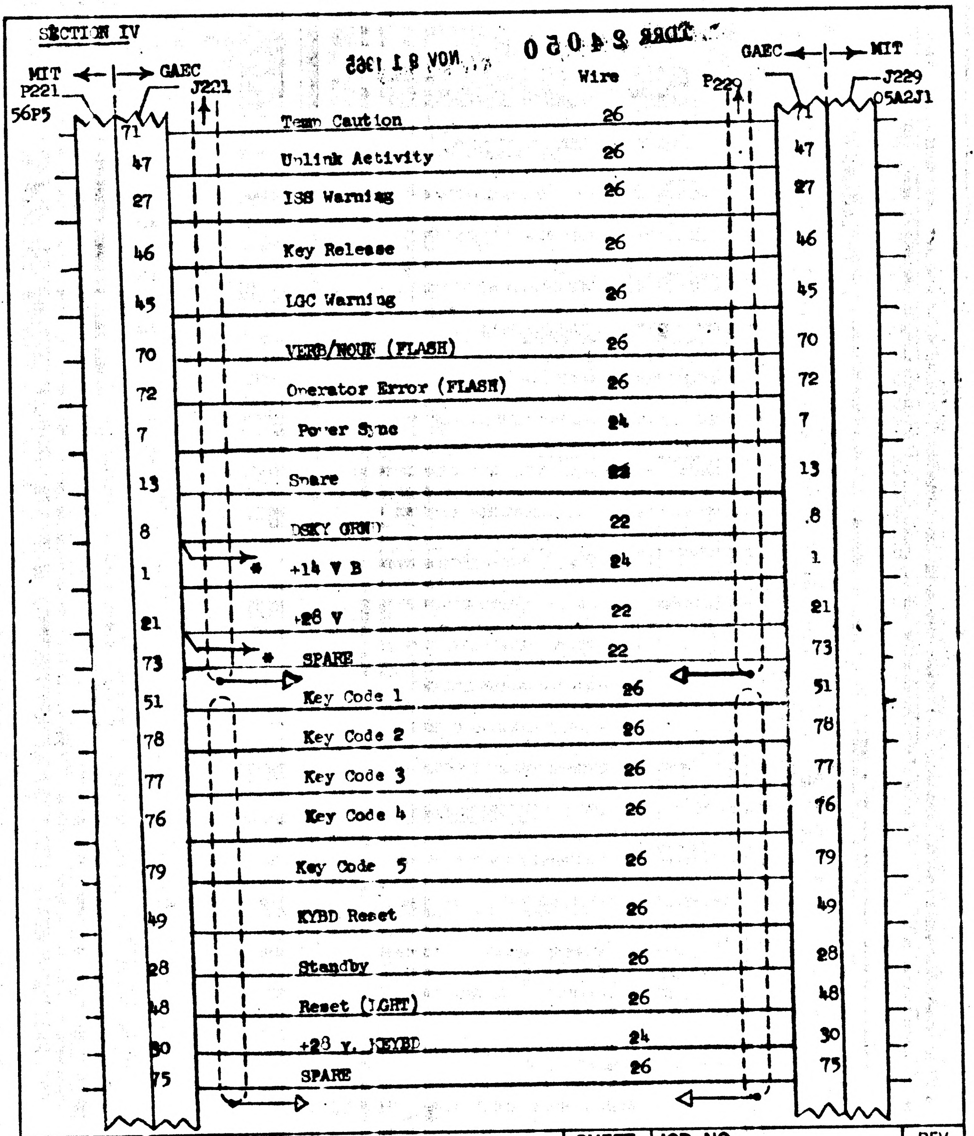


J221		Wire	J229
2	CHN 10 (OUT "0")-1	26	2
9	* CHN 10 (OUT "0")-2	26	9
22	* CHN 10 (OUT "0")-3	26	22
41	* CHN 10 (OUT "0")-4	26	41
66	* CHN 10 (OUT "0")-5	26	66
3	* CHN 10 (OUT "0")-6	26	3
10	* CHN 10 (OUT "0")-7	26	10
23	* CHN 10 (OUT "0")-8	26	23
42	* CHN 10 (OUT "0")-9	26	42
67	CHN 10 (OUT "0")-10	26	67
12	CHN 10 (OUT "0")-11	26	12
11	CHN 10 (OUT "0")-12	26	11
24	* CHN 10 (OUT "0")-13	26	24
43	* CHN 10 (OUT "0")-14	26	43
68	* CHN 10 (OUT "0")-15	26	68
74	* SPARE	22	74
26	Computer Activity	26	26
25	Stand by lamp	26	25
44	Restart	26	44
69	LRDP Pos. Command	26	69
18	RRDR Enable Lock	26	18

	SHEET	ICD NO.	REV
INTERFACE CONTROL DOCUMENT	42 OF 45	LIS 370-10004	A

ENG 37.2 1-64

SECTION IV

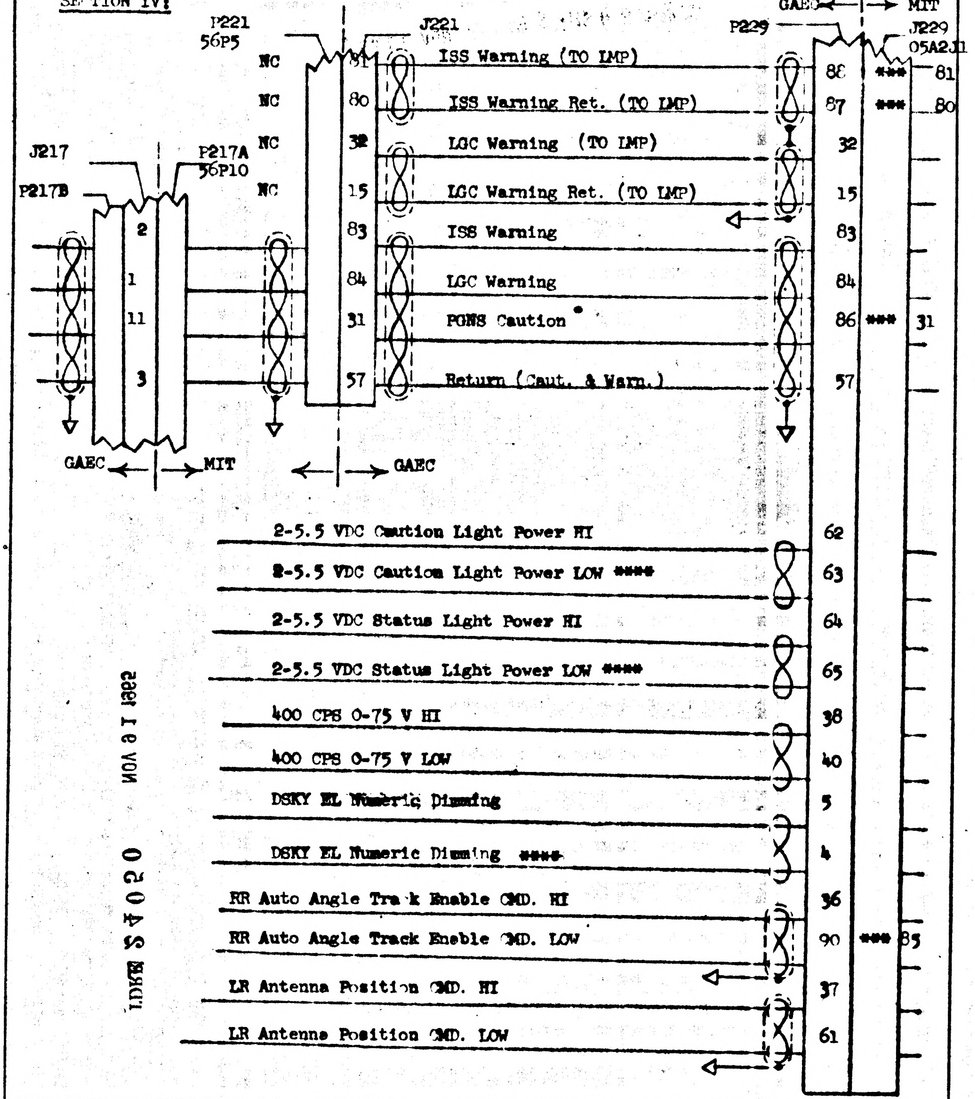


J221		Wire	J229
71	Temp Caution	26	71
47	Uplink Activity	26	47
27	ISS Warning	26	27
46	Key Release	26	46
45	LGC Warning	26	45
70	VERB/NOUN (FLASH)	26	70
72	Operator Error (FLASH)	26	72
7	Power Sync	24	7
13	Spare	24	13
8	DSKY GRND	22	8
1	* +14 V B	24	1
21	+28 V	22	21
73	* SPARE	22	73
51	Key Code 1	26	51
78	Key Code 2	26	78
77	Key Code 3	26	77
76	Key Code 4	26	76
79	Key Code 5	26	79
49	KYBD Reset	26	49
28	Standby	26	28
48	Reset (LGHT)	26	48
30	+28 V, KEYBD	24	30
75	SPARE	26	75

	SHEET	ICD NO.	REV
INTERFACE CONTROL DOCUMENT	43 OF 45	LIS 370-10004	A

ENG 37.2 1-64

SECTION IV:


P221
56P5
J221
P229
GAEC
MIT
J229
05A2J1
J217
P217B
P217A
56P10
NC
NC
NC
NC
81
80
32
15
83
84
31
57
2
1
11
3
ISS Warning (TO LMP)
ISS Warning Ret. (TO LMP)
LGC Warning (TO LMP)
LGC Warning Ret. (TO LMP)
ISS Warning
LGC Warning
PGNS Caution *
Return (Caut. & Warn.)
88
87
32
15
83
84
86
57
***
***
***
81
80
31
GAEC
MIT
GAEC
2-5.5 VDC Caution Light Power HI
2-5.5 VDC Caution Light Power LOW ****
2-5.5 VDC Status Light Power HI
2-5.5 VDC Status Light Power LOW ****
400 CPS 0-75 V HI
400 CPS 0-75 V LOW
DSKY EL Numeric Dimming
DSKY EL Numeric Dimming ****
RR Auto Angle Track Enable CMD. HI
RR Auto Angle Track Enable CMD. LOW
LR Antenna Position CMD. HI
LR Antenna Position CMD. LOW
62
63
64
65
38
40
5
4
36
90
37
61
***
85

TDRR 24050
NOV 9 1 1965

SECTION IV:

NOV 9 1 1965
TDRR 24050

NOTES:

* Indicates leads which will be tapped off to drive LMP Command Coupler in unmanned LEMs. Leads to Command Coupler must be adequately shielded.

** Indicates signals which will also be sent to ACE via the PSA Adapter Module. This interface will be covered in LID 410-10003.

*** Pins shown are for the 91 pin DSKY connector. These pins change to those shown in the right hand margin when the 85 pin DSKY connector is used.

**** Shielding of these wires is to be determined.

TDRR 35886 — MAR 21 1968

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	
W Stameris	MIT	23 Sept 1966

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512	**IRN NO:** SH. 1 of 2 LIS 390-10002-2
	ICRA NO: 10-089 SH. 2 of 5
ICD NO. LIS 390-10002	
CCA NO.	**DATE** 9-26 66
ICD TITLE PGNS Prime Power Requirements and Characteristics	

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

SHEET 8:

Replace with new sheet (Sheet 2 of the IRN)

Effectivity: LTA-1, LTA-1R, LTA-8, LM 1 thru 15

REASON: Deletion of LGC D.C. return wire to N_2 Bus

DRAWN BY: R. Kerr

ENG 37.3 1-66

JDRK 35886 MAR 21 1968

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E. Shr	GAEC	
WStamerus	MIT	13 Oct 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No.697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO: 26512

IRN NO: LIS 390-10002-3
Sheet 1 of 1

ICRA NO: 10-079
Page [illegible] of [illegible] 12-5-9

ICD NO. LIS-390-10002

CCA NO.

DATE

ICD TITLE
PGNS prime power requirements and characteristics

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Ref. - Sheet 1: In EFFECTIVITY zone, add the following:

—	EMI, LTA-1, LTA-1R, LTA-8, LEM 1 thru 15
REV	Model

REASON: Add vehicle effectivity

DRAWN BY: M. MALISON

REF: CCA 487

TDRR 35136 NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J E Morris	GAEC	11/21/67
W. Stameris	MIT 16 Nov	1967

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: Sheet 1 of 1 LIS 390-10002-~~3~~-5

ICRA NO: 10-241 Sheet 6 of 6

ICD NO. LIS 390-10002

CCA NO. DATE

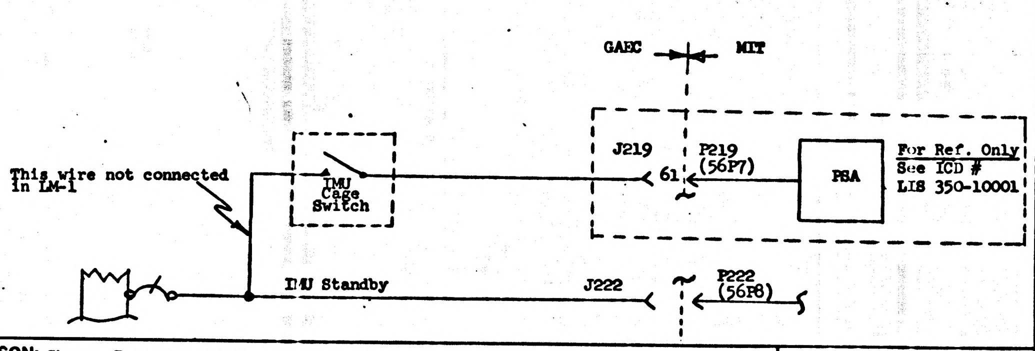
ICD TITLE FGNS Prime Power Requirements and Characteristics

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

This IRN Modifies IRN #4 against this ICD

On Sheet 8 of IRN #LIS 390-10002-4, change IMU Standby circuit as shown below:


GAEC
MIT
This wire not connected in LM-1
IMU Cage Switch
J219
61
P219 (56P7)
PSA
For Ref. Only
See ICD # LIS 350-10001
IMU Standby
J222
P222 (56P8)

REASON: Change Power Source for IMU Cage Command

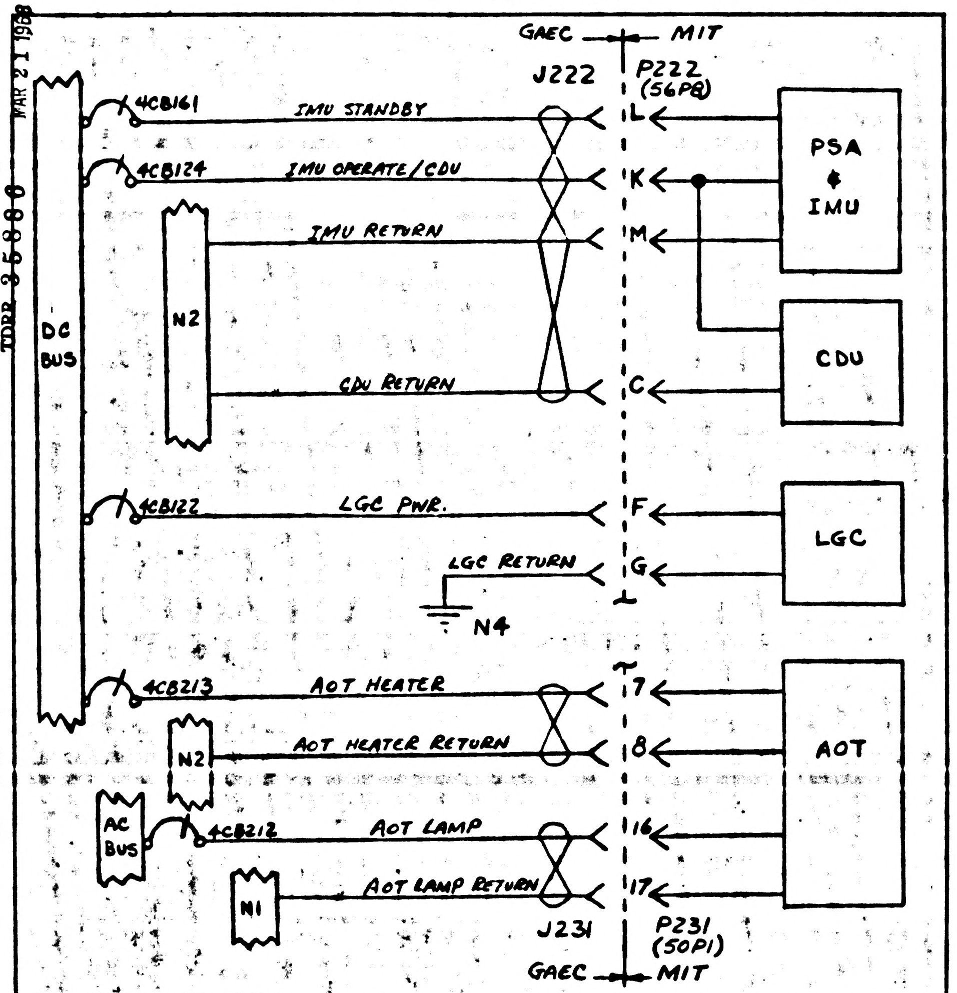
DRAWN BY: R. Kerr

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

ue 9/23/66

TDRR 35880
MAR 21 1968


GAEC
MIT
J222
P222
(56P8)
DC BUS
4CB161
IMU STANDBY
4CB124
IMU OPERATE/CDU
N2
IMU RETURN
CDU RETURN
L
K
M
C
PSA & IMU
CDU
4CB122
LGC PWR.
LGC RETURN
N4
F
G
LGC
4CB213
AOT HEATER
N2
AOT HEATER RETURN
AC BUS
4CB212
AOT LAMP
N1
AOT LAMP RETURN
7
8
16
17
AOT
J231
P231
(50P1)
GAEC
MIT

N1 = A.C. Ground Bus
N2 = D.C. Ground Bus
N4 = Structure Ground

Connector Types Defined in ICD # LID 390-10001

IRN# LIS 390-10002-2

Sh. 2 of 2

ICRA 10-089

FIGURE 2. - Power Distribution System

Sh. 3 of 5

INTERFACE CONTROL DOCUMENT	SHEET 8 OF 8	ICD NO. LIS 390-10002	REV

GAD 37.2 1-64

REV

ICD NO. LIS 410-10002

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

TDRR 27057

INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	[illegible]
	MIT/IL	[illegible]

PREPARED BY: S. Roberts

CHECKED:

TITLE:

INERTIAL COMPONENTS TEMPERATURE CONTROL SYSTEM INTERFACE

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	1 OF 13	LIS 410-10002	

INTERFACE CONTROL DOCUMENT

ENG 37 1-64

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
					GAEC		

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4.2	Electrical Interface	9
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Fig. 2	PTC/Cable "C" Interface	11
Fig. 3	W197/Cable "B"/LEM Interface	12
Fig. 4	W197/Cable "D"/W198 Interface	13

GLOSSARY OF TERMS

IMU	Inertial Measurement Unit
LEM	Lunar Excursion Module
PTC	Portable Temperature Controller
PNGS	Primary Navigation and Guidance System
LBP	Lifting Battery Pack
BPP	Battery Power Pack
LID	LEM Interface Drawing
LIS	LEM Interface Specification
ICD	Interface Control Document
ICTCMAP	Inertial components temperature controller monitor and alarm panel

KEY

Responsibility is identified herein as follows:

(1) Grumman Aircraft Engineering Corporation
Bethpage, Long Island, New York

(2) Massachusetts Institute of Technology
Cambridge, Massachusetts

(3) National Aeronautics and Space Administration
Manned Space Center

(4) Design Data to be supplied by:

TDRK 35886 MAR 21 1968

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	
WStameris	MIT	13 Oct 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No.697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: LIS 410-10002-2
Sheet 1 of 1

ICRA NO: 10-079
Page 13 of 19

ICD NO. LIS-410-10002

CCA NO. DATE 10/13/66

ICD TITLE
Inertial components temperature control system interface

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Ref. - Sheet 1: In EFFECTIVITY zone, add the following:

—	ESI, LTA-1, LTA-1R, LTA-8, LEM 1 thru 15
REV	Model

REASON: Add vehicle effectivity

DRAWN BY: S Roberts

GAC 37.3 1-64

1.0 SCOPE

This ICD will establish the electrical provisions for the IMU/PTC and LEM/PTC interfaces. The Portable Temperature Controller and associated hardware constitutes the Inertial Components Temperature Control System which will be used to provide the following when the system is not vehicle powered.

a) Heater power to the inertial components

b) Temperature control of the IMU

c) Alarm signals whenever the IMU temperature is out of limit or electrical power is lost

d) Remote alarm signals

2.0 APPLICABLE DOCUMENTATION

ITEM

MIT/GAEC ICD LID 390-10091

MIT/GAEC ICD LID 410-10002

3.0 REQUIREMENTS

3.1 The PTC is inherently designed for operation in various atmospheric conditions but in no case shall the PTC be used in high temperature, explosive or high vacuum environments

3.2 The cables as shown on page 8 shall be provided according to the table below with the following lengths:

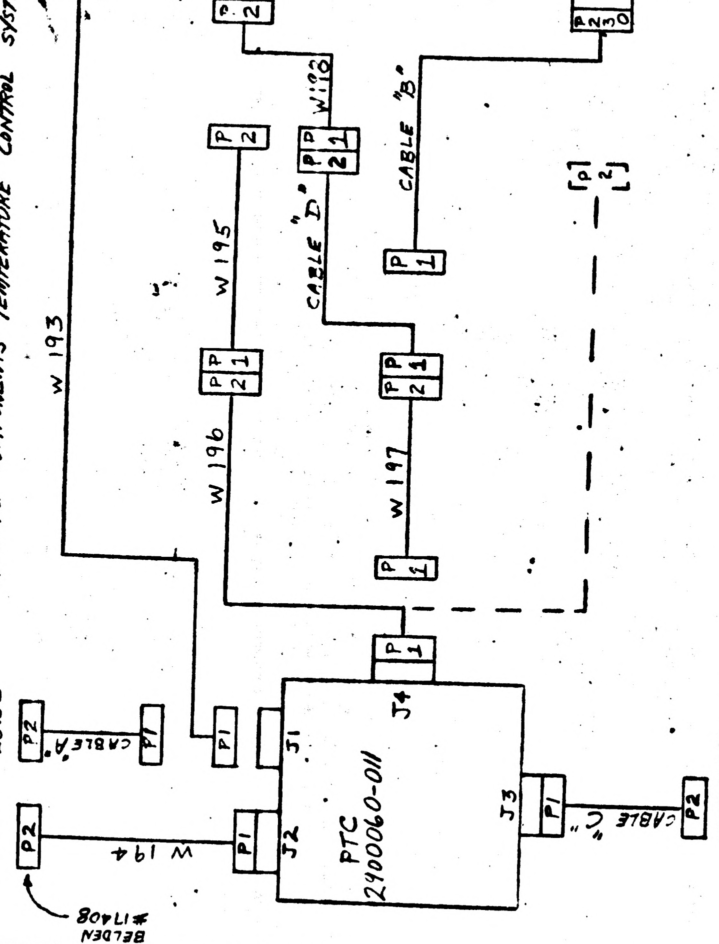
CABLE DESIGNATION	MIN. CABLE LENGTH (ft)	PROVIDED BY	PROVIDED WITH
W193	15	MIT	LBP
W194	7	MIT	PTC
W195	1.0	MIT	PTC
W196	14	MIT	PTC
W197	1.0	MIT	PTC
W198	9	MIT	N.A.
Cable "A"	NA	GAEC	GAEC Site Facility
Cable "B"	(4) (1)	GAEC	GAEC SITE Facility
Cable "C"	(4) (1)	GAEC	GAEC Site Facility
Cable "D"	(4) (1)	GAEC	GAEC Site Facility

3.3 The cable impedances between pins J,L,X,V,K,I,U and W, and the termination of cables "B" and "D", shall not exceed 0.8 ohms.

3.4 The cable impedances between pins G,H,Z,A,a,D, and C, and the termination of cables "B" and "D" shall not exceed 4.0 ohms.

3.5 The cable impedances between pins K and L of the PTC connector J1 and termination shall not exceed 0.4 ohms.

4.0 GENERAL CONFIGURATION OF INERTIAL COMPONENTS TEMPERATURE CONTROL SYSTEM



NOTE: 1. CABLES "A", "B", "C" AND "D" ARE THE GAEC INTERFACES WITH MIT/GFE.
2. FOR SHORT RUNS, THE PTC IS CONNECTED TO THE IMU BK II VIA CABLES W196 & W195 OR W197 & W198 AND TO THE LEM WITH CABLE W196.

4.1 MECHANICAL CONFIGURATION

The mechanical interface documenting the size, weight, and mounting configuration is controlled by ICD # LID 410-10002.

4.2 Electrical Interface

The controlling document for connector type and pin assignments for the MIT/GAEC Interface at J230 will be the electrical wiring ICD #LID 390-10001.

PTC/CABLE "A" INTERFACE

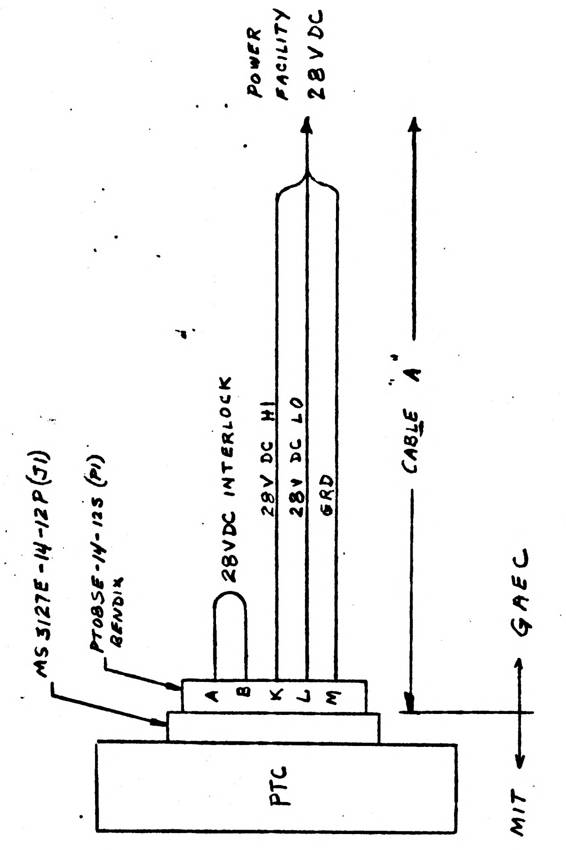

MS 3127E-14-12P (J1)
PTO8SE-14-12S (P1) BENDIX
A
B
K
L
M
28VDC INTERLOCK
28V DC HI
28V DC LO
GRD
POWER FACILITY 28VDC
CABLE "A"
PTC
MIT
GAEC

FIG. 1

NOTE
1. CONTACTS A AND B OF CONN (P1) ARE JUMPERED.

PTC/CABLE "C" INTERFACE

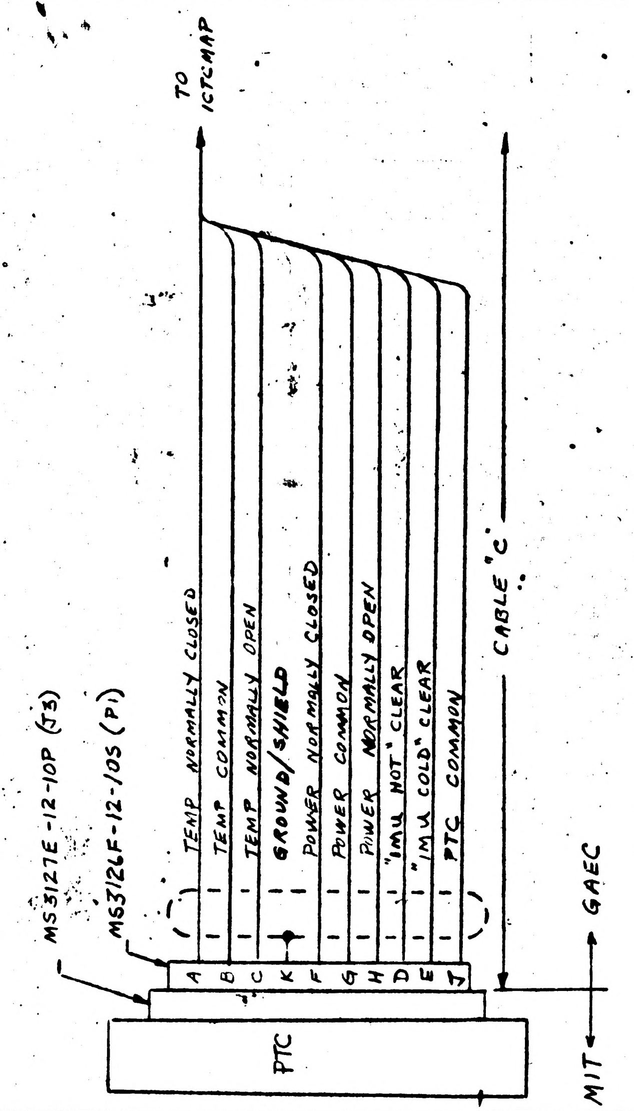

MS3127E-12-10P (J3)
MS3126F-12-10S (P1)
A
B
C
K
F
G
H
D
E
J
TEMP NORMALLY CLOSED
TEMP COMMON
TEMP NORMALLY OPEN
GROUND/SHIELD
POWER NORMALLY CLOSED
POWER COMMON
POWER NORMALLY OPEN
"IMU HOT" CLEAR
"IMU COLD" CLEAR
PTC COMMON
TO ICT CMAP
CABLE "C"
PTC
MIT
GAEC

FIG. 2

W 197/CABLE "B"/LEM INTERFACE

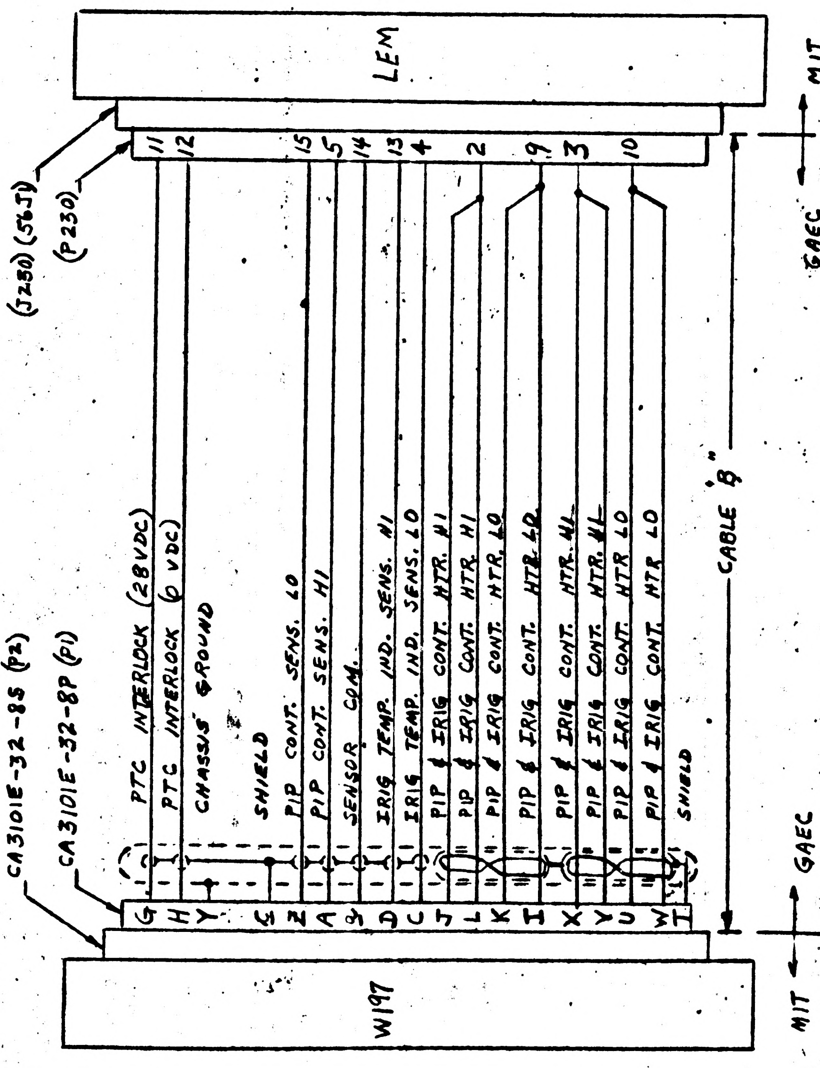

CA3101E-32-8S (P2)
CA3101E-32-8P (P1)
(J230) (56J)
(P230)
G
H
Y
S
N
A
B
D
C
J
L
K
H
X
U
W
T
PTC INTERLOCK (28VDC)
PTC INTERLOCK (0 VDC)
CHASSIS GROUND
SHIELD
PIP CONT. SENS. LO
PIP CONT. SENS. HI
SENSOR COM.
IRIG TEMP. IND. SENS. HI
IRIG TEMP. IND. SENS. LO
PIP & IRIG CONT. HTR. HI
PIP & IRIG CONT. HTR. HI
PIP & IRIG CONT. HTR. LO
PIP & IRIG CONT. HTR. LO
PIP & IRIG CONT. HTR. HI
PIP & IRIG CONT. HTR. HI
PIP & IRIG CONT. HTR. LO
PIP & IRIG CONT. HTR LO
SHIELD
11
12
15
5
14
13
4
2
9
3
10
LEM
W197
CABLE "B"
MIT
GAEC

FIG. 3

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

W197/ CABLE "D"/ W198 INTERFACE

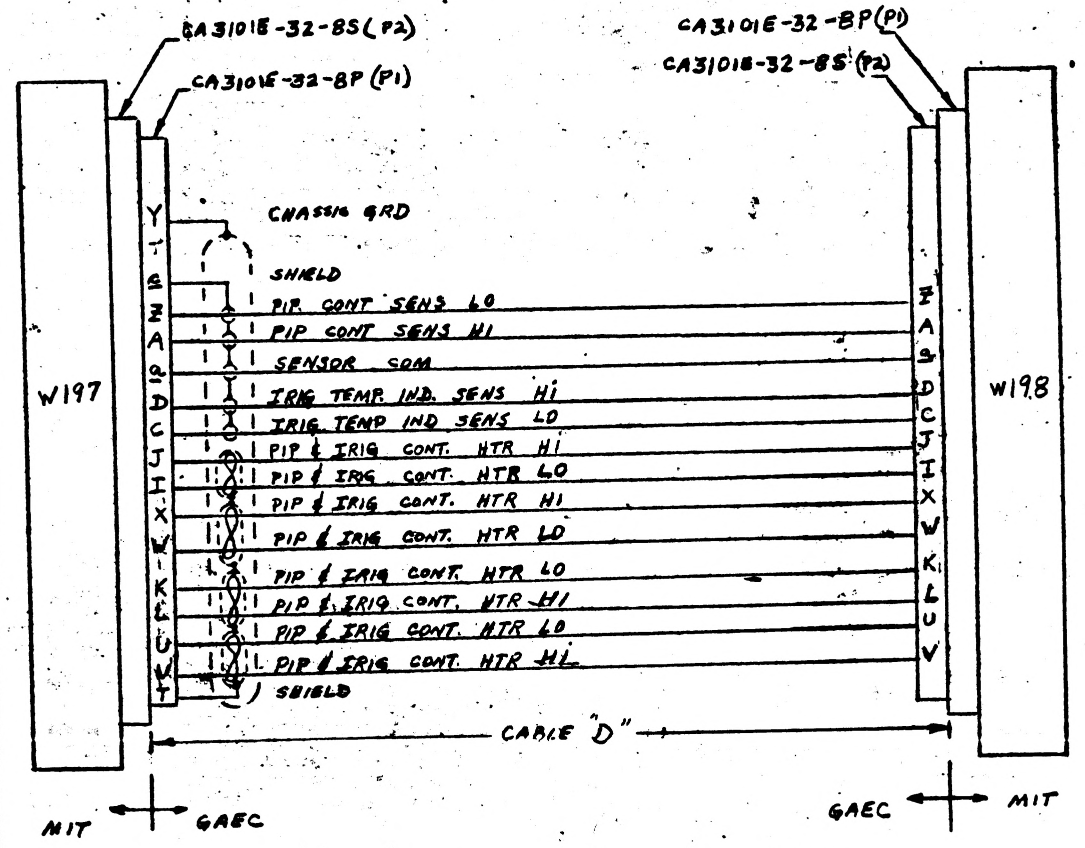

CA3101E-32-8S(P2)
CA3101E-32-8P(P1)
CA3101E-32-8P(P1)
CA3101E-32-8S(P2)
W197
W198
CHASSIS GRD
SHIELD
PIP CONT SENS LO
PIP CONT SENS HI
SENSOR COM
IRIG TEMP. IND. SENS HI
IRIG TEMP IND SENS LO
PIP & IRIG CONT. HTR HI
PIP & IRIG CONT. HTR LO
PIP & IRIG CONT. HTR HI
PIP & IRIG CONT. HTR LO
PIP & IRIG CONT. HTR LO
PIP & IRIG CONT. HTR HI
PIP & IRIG CONT. HTR LO
PIP & IRIG CONT. HTR HI
SHIELD
Y
T
s
Z
A
a
D
C
J
I
X
W
K
L
U
V
T
Z
A
a
D
C
J
I
X
W
K
L
U
V
CABLE "D"
MIT
GAEC
GAEC
MIT

FIG 4.

INTERFACE CONTROL DOCUMENT

SHEET	ICD NO.	REV
13 OF 13	LIB 410-10002	

AUTHORIZED SIGNATURES	REPRESENTING	DATE
E Stern	GAEC	8/16/66
W. Stameris	MIT/IL	23 May 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO 26512

IRN NO: LIS 410-10003-1 sheet 1 of 1

ICRA NO: sheet 2 of 2 10-126 Rev/[illegible]

ICD NO. LIS-410-10003

CCA NO.

DATE 8-16-66

ICD TITLE Power & Servo Assembly (PSA) Adapater Module Electrical Interface

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION: SHEETS 8 and 9 of 14

Designate	P243-6	Line	As	DG 2501
"	P243-28	"	"	DG 2502
"	P243-14	"	"	DG 2503
"	P243-30	"	"	DG 2504
"	P243-32	"	"	JG 2505
"	P243-16	"	"	JG 2506
"	P243-34	"	"	JG 2507
"	P243-18	"	"	JG 0021

Remove Signal Designations from Each of the following lines and replace with "GAEC 28VDC NOM. 30 ma max" JAL

P243-5
P243-13
JAL P243-29
P243-31
P243-15
JAL P243-33
P243-17
P243-35

TDRR
31851
28 Nov 1966

REASON: To incorporate electrical characteristics of two-wire signals

DRAWN BY: G. McWeeney

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

TDRR 27057

INTERFACE CONTROL DOCUMENT

ICD NO. LIS-410-10003

REV

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
[illegible]	GAEC	[illegible]
W. St[illegible] EAO	MIT	[illegible]

PREPARED BY: Charles Jaslow

CHECKED: S. [illegible]

TITLE: POWER AND SERVO ASSEMBLY (PSA) ADAPTER MODULE ELECTRICAL INTERFACE

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	SHEET 1 OF 14	LIS-410-10003	

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS GAEC	APPROVALS	DATE

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
	2 OF 14	LIS-410-10003	

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

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	Glossary of Terms
1.0	Scope
2.0	Connecter designation and part numbers
3.0	Definition of Interface Connectors and Associated Cabling
3.1	Interfacing Cable Sets
3.2	GAEC/MIT Interface for the GSE Supplied Stimuli and the ACE Uplink for the LGC
3.3.	GAEC/MIT Interface for GSE Measurements
3.4.	GAEC/MIT Interface for the PIPA Hardline Downlink
3.5	Down Link PIPA Cabling

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
	3 OF 14	LIS-410-10003	

ENG 37.2 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

GLOSSARY of TERMS

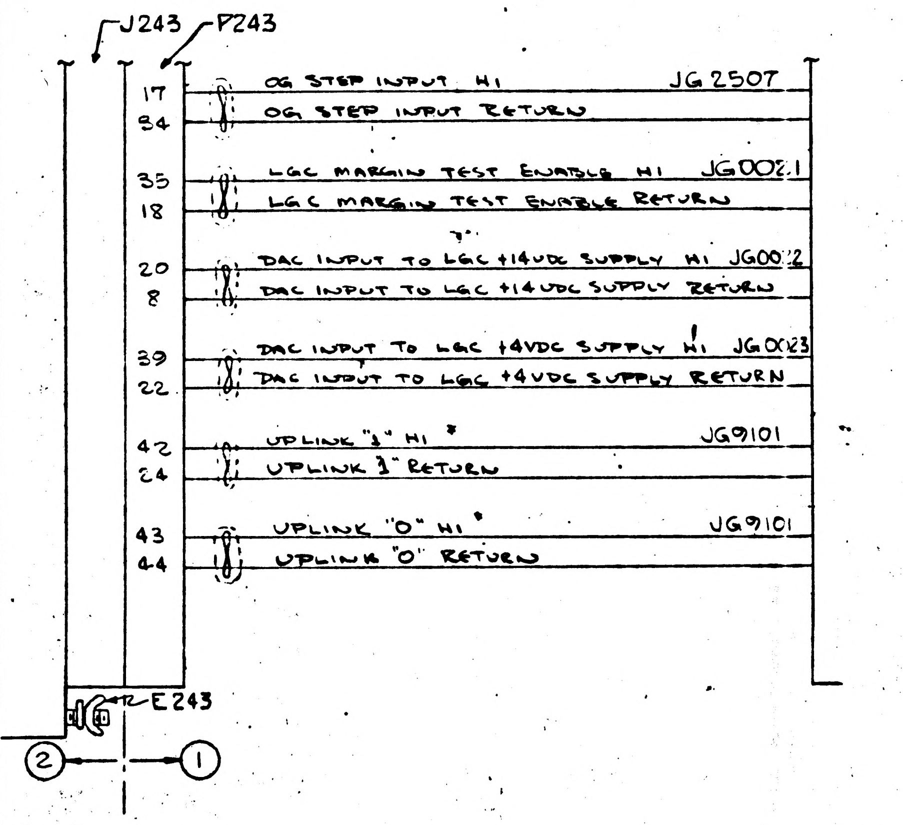
1- Grumman Aircraft Engineering Corp.
2- Massachusetts Institute of Technology Inst. Lab
3- Design Data to be supplied

CDU	Coupling Data Unit
DAC	Digital to Analog Converter
G & N	Guidance and Navigation
GAEC	Grumman Aircraft Engineering Corp.
GSE	Ground Support Equipment
ICD	Interface Control Document
IG	Inner Gimbal
IMU	Inertial Measurement Unit
IRIG	Inertial Rate Integrating Gyro
KSC	Kennedy Space Center
LEM	Lunar Excursion Module
LGC	LEM Guidance Computer
LIS	LEM Interface Specification
MG	Middle Gimbal
MIT	Massachusetts Institute of Technology
MIT/IL	Massachusetts Institute of Technology Inst. Lab
OG	Outer Gimbal
P	Per Cent
PIPA	Pulse Integrating Pendulous Accelerometer
PSA	Power and Servo Assembly
TRUN	Trunnion

INTERFACE CONTROL DOCUMENT	SHEET	ICD NO.	REV
	4 OF 14	LIS-410-10003	

ENG 37.2 1-64

Connector J243/P243 Interface Continued



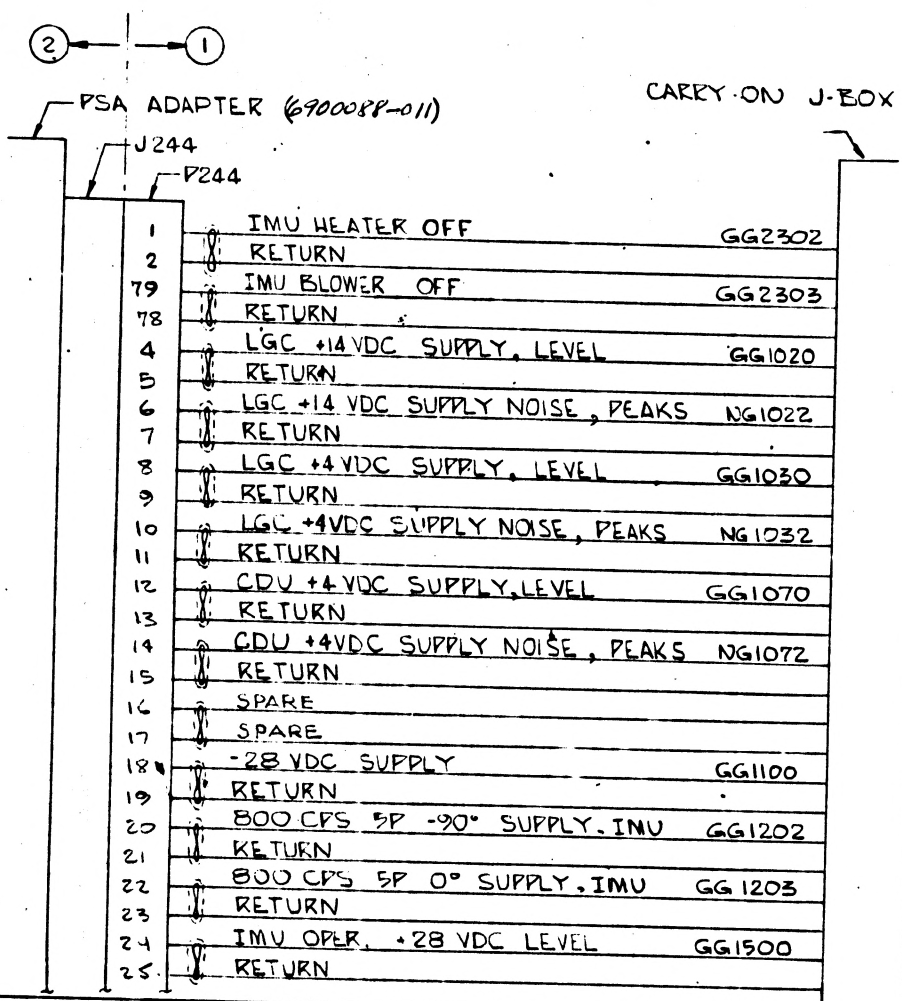
17	OG STEP INPUT HI	JG2507
34	OG STEP INPUT RETURN	
35	LGC MARGIN TEST ENABLE HI	JG0021
18	LGC MARGIN TEST ENABLE RETURN	
20	DAC INPUT TO LGC +14VDC SUPPLY HI	JG0022
8	DAC INPUT TO LGC +14VDC SUPPLY RETURN	
39	DAC INPUT TO LGC +4VDC SUPPLY HI	JG0023
22	DAC INPUT TO LGC +4VDC SUPPLY RETURN	
42	UPLINK "1" HI *	JG9101
24	UPLINK "1" RETURN	
43	UPLINK "0" HI *	JG9101
44	UPLINK "0" RETURN	

NOTE: All shields on the cable interfacing with P243 will be tied to a Thomas and Betts "Hyring" (or equivalent). The "Hyring" will contain one (1) pigtail of #12 wire no greater than 3" in length terminated with a spade lug. The spade lug will be connected to E243 using a tooth type star washer in combination with the associated wingnut of E243.

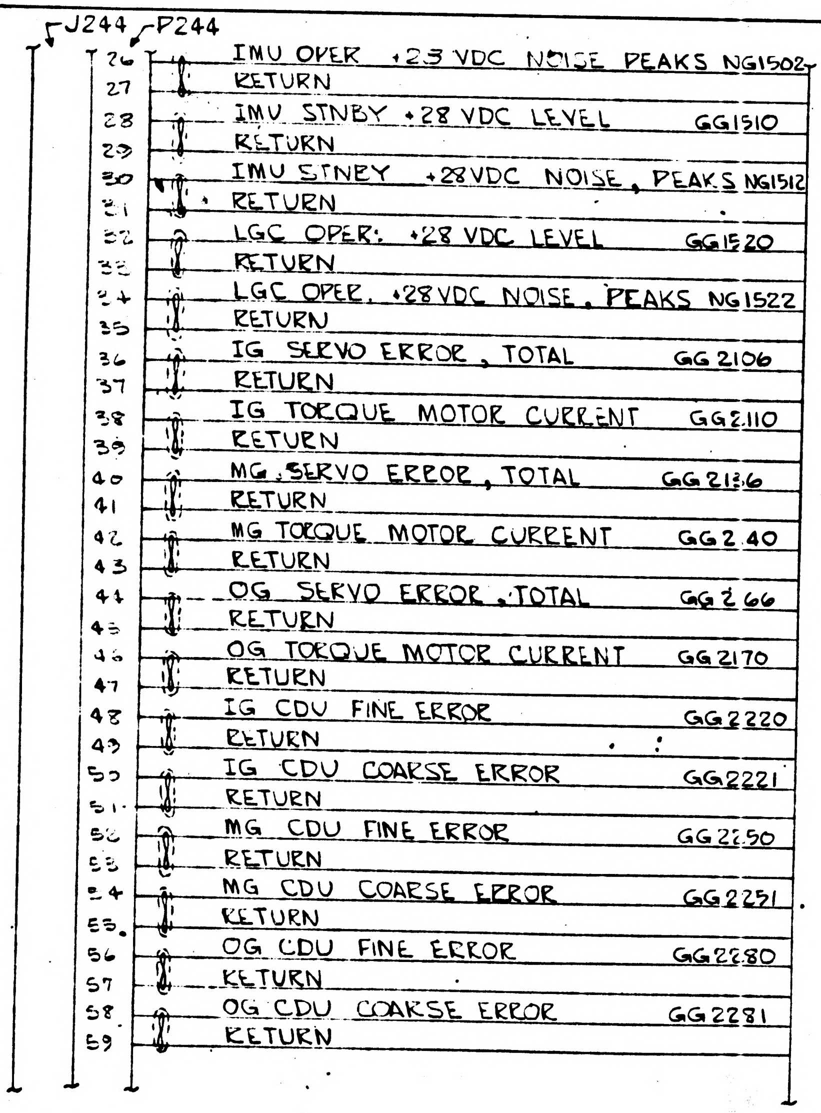
* G & N BUFFER DATA TO LGC

3.3. GAEC/MIT Interface for GSE Measurements

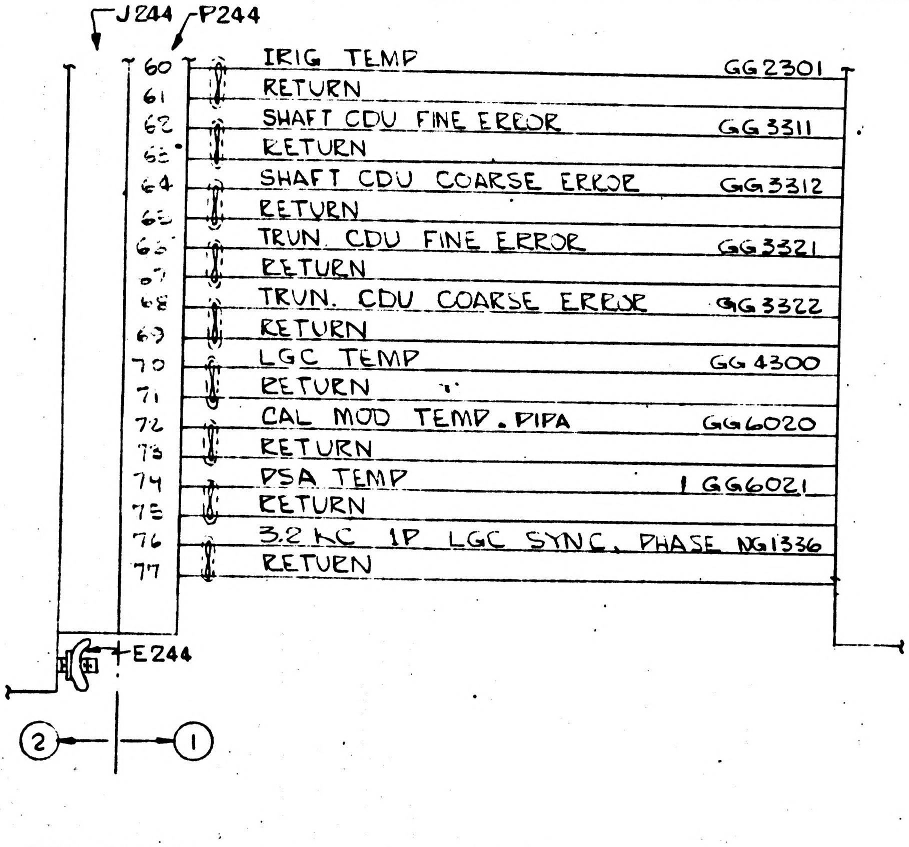
Connector J244/P244 Interface



1	IMU HEATER OFF	GG2302
2	RETURN	
79	IMU BLOWER OFF	GG2303
78	RETURN	
4	LGC +14 VDC SUPPLY, LEVEL	GG1020
5	RETURN	
6	LGC +14 VDC SUPPLY NOISE, PEAKS	NG1022
7	RETURN	
8	LGC +4 VDC SUPPLY, LEVEL	GG1030
9	RETURN	
10	LGC +4VDC SUPPLY NOISE, PEAKS	NG1032
11	RETURN	
12	CDU +4 VDC SUPPLY, LEVEL	GG1070
13	RETURN	
14	CDU +4VDC SUPPLY NOISE, PEAKS	NG1072
15	RETURN	
16	SPARE	
17	SPARE	
18	-28 VDC SUPPLY	GG1100
19	RETURN	
20	800 CPS 5P -90° SUPPLY. IMU	GG1202
21	RETURN	
22	800 CPS 5P 0° SUPPLY. IMU	GG1203
23	RETURN	
24	IMU OPER. +28 VDC LEVEL	GG1500
25	RETURN	



26	IMU OPER +25 VDC NOISE PEAKS	NG1502
27	RETURN	
28	IMU STNBY +28 VDC LEVEL	GG1510
29	RETURN	
30	IMU STNBY +28VDC NOISE, PEAKS	NG1512
31	RETURN	
32	LGC OPER. +28 VDC LEVEL	GG1520
33	RETURN	
34	LGC OPER. +28VDC NOISE, PEAKS	NG1522
35	RETURN	
36	IG SERVO ERROR, TOTAL	GG2106
37	RETURN	
38	IG TORQUE MOTOR CURRENT	GG2110
39	RETURN	
40	MG SERVO ERROR, TOTAL	GG2136
41	RETURN	
42	MG TORQUE MOTOR CURRENT	GG2140
43	RETURN	
44	OG SERVO ERROR, TOTAL	GG2166
45	RETURN	
46	OG TORQUE MOTOR CURRENT	GG2170
47	RETURN	
48	IG CDU FINE ERROR	GG2220
49	RETURN	
50	IG CDU COARSE ERROR	GG2221
51	RETURN	
52	MG CDU FINE ERROR	GG2250
53	RETURN	
54	MG CDU COARSE ERROR	GG2251
55	RETURN	
56	OG CDU FINE ERROR	GG2280
57	RETURN	
58	OG CDU COARSE ERROR	GG2281
59	RETURN	

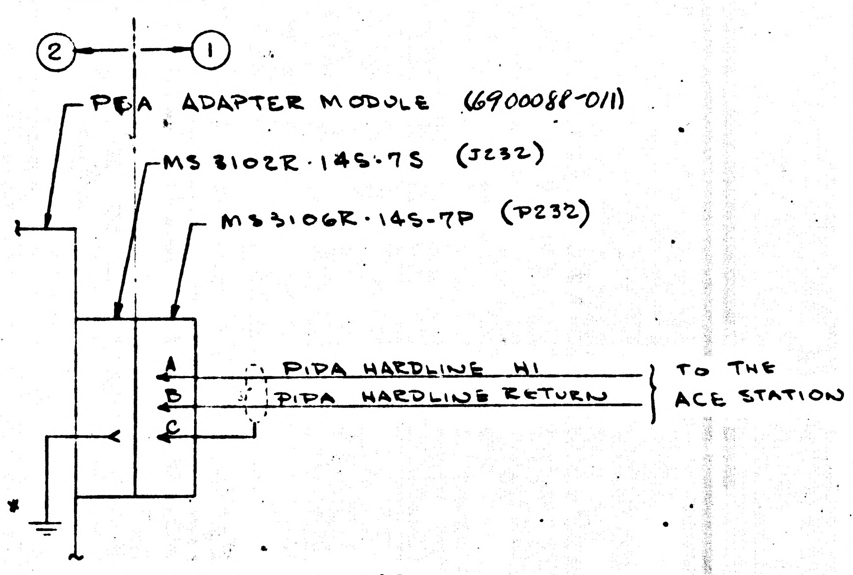


60	IRIG TEMP	GG2301
61	RETURN	
62	SHAFT CDU FINE ERROR	GG3311
63	RETURN	
64	SHAFT CDU COARSE ERROR	GG3312
65	RETURN	
66	TRUN. CDU FINE ERROR	GG3321
67	RETURN	
68	TRUN. CDU COARSE ERROR	GG3322
69	RETURN	
70	LGC TEMP	GG4300
71	RETURN	
72	CAL MOD TEMP. PIPA	GG6020
73	RETURN	
74	PSA TEMP	GG6021
75	RETURN	
76	3.2 KC 1P LGC SYNC. PHASE	NG1336
77	RETURN	

NOTE: All shields on the cable interfacing with P244 will be tied to a Thomas and Betts "Hyring" (or equivalent). The "Hyring" will contain two (2) pigtails, each of #12 wire no greater than 3" in length, both terminated with a single spade lug. The spade lug will be connected to E244 using a tooth type star washer in combination with the associated wingnut of E244.

3.4 GAEC/MIT Interface for PIPA Hardline Downlink

Connector J232/P232 Interface


2
1
PSA ADAPTER MODULE (6900088-011)
MS 3102R-14S-7S (J232)
MS3106R-14S-7P (P232)
A
B
C
PIPA HARDLINE HI
PIPA HARDLINE RETURN
TO THE ACE STATION
*

* Grounded inside the PSA Adapter Module

On this downlink hardline the following signals will be monitored:

1) X-PIPA Mode Check GG 2011
2) Y-PIPA Mode Check GG 2031
3) Z-PIPA Mode Check GG 2051
4) 3.2 KCPS Supply Ref. GG 1331

3.5 Down Link PIPA Cabling

KSC-

At this location LSC-C0813-1 will be the cable for the monitoring of the PIPA downlink signals.

Bethpage Facility-

At this facility T-43 video pair cable will be used, 125 ohm balanced pair.

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	5/22/68
W.A. Stameris	MIT/IL	22 May 68

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS 420-10001 A-
Sheet 1 of 2
ICRA NO: 10-155
Page 2 of 3
ICD NO. LIS 420-10001 Rev. A
CCA NO. **DATE**
ICD TITLE
PGNCS Installation Fixtures and Procedures

TDRR 36676
AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Renumber paragraph 4.4.8 to 4.4.15 and insert the following paragraphs 4.4.8 - 4.4.14:

4.4.8 Complete the electrical connection between the power connector J-1 on the PTC and the 115 VAC power source.

4.4.9 Hold the Power On switch to the Heater Current position. Verify heater current between .5 amps and 1.5 amps on PTC meter. Release switch.

4.4.10 Verify GAEC furnished notifier cable is disconnected from PTC connector J-3.

4.4.11 Press and hold 130°F calibration button and verify PTC meter indicates 130° ± .5°F. Release button.

4.4.12 Verify IMU temperature indicates between 129°F and 131°F on the PTC meter.

4.4.13 Press and hold 125°F calibration button and verify "IMU COLD" alarm lights, PTC meter indicates 125°F ± .5°F, and alarm bell rings. Press alarm reset and verify bell goes off, and "IMU COLD" lights remain on. Release 125°F calibration button and press "Alarm Reset" button. Verify temperature on PTC meter indicates 130°F ± .5°F, and no alarm lights are on.

REASON: To verify PTC operation

DRAWN BY: R. Maselek

ENG 37.3 1-64

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	5/22/68
W.A. Stameris	MIT/IL	22 May 68

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS 420-10001A-1
Sheet 2 of 2
ICRA NO: 10-155
Page 3 of 3
ICD NO. LIS 420-10001 Rev. A
CCA NO. **DATE**
ICD TITLE
PGNCS Installation Fixtures and Procedures

TDRR 36676
AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

4.4.14 Press and hold 138°F calibration button. Verify PTC meter indicates 138°F ± .5°F, "IMU HOT" alarm lights and alarm bell rings. Release 138°F calibration button and press "Alarm Reset." Verify temperature on PTC meter indicates 130° ± .5°F and no alarm lights are on.

REASON: To verify PTC operation

DRAWN BY: R. Maselek

ENG 37.3 1-64

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	Rev. 7/26/68 6/10/68
WStameris	MIT	30 July 1968

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No. 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS-420-10001A-2
Sheet 1 of 2
ICRA NO: 10-260
Page 3 of 4
ICD NO. LIS-420-10001A
CCA NO. DATE
ICD TITLE
PGNS Installation Fixtures and Procedures

IDRR 36676 AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

1. Add the following after Section 4.3.2

Note: Sections 4.3.2.1 through 4.3.2.3 apply to LM-4 and subsequent only.

4.3.2.1 Remove all AOT mounting screws from AOT pressure seal mounting flange except four screws marked with "A". Observe relation of index mark to screws removed. Place screws in plastic box for later installation of bellows.

4.3.2.2 Obtain bellows assembly, 6011869. Slide bellows assembly over AOT outer tube seal flange from prism end.

4.3.2.3 Obtain split ring, 6011227 (-1 and -2) and six soc. hd. cap screws NAS 1352C02 LL3. Install split ring on lower portion of bellows assembly using the six soc. hd. cap screws. Torque screws to 1.8 ± 0.1 inch-pounds.

NOTE: Items 4.3.2.1, 4.3.2.2 & 4.3.2.3 must be done before AOT is installed into LM Vehicle.

2. Add the following after Section 4.3.12

NOTE: Sections 4.3.12.1 through 4.3.12.5 apply to LM-3 only.

4.3.12.1 Tighten twelve (12) AOT seal screws inserted in AOT flange to 13.5 in/lbs. per sequence noted in paragraph 4.3.12.

4.3.12.2 Obtain two clamps (6011874 & 6011875) and proceed as follows:-

4.3.12.2.1 Insert 6 screws (6011236) into the two clamps from the surface opposite the groove. Engage the screws approx. 1 thread only.

4.3.12.2.2 Insert the 6 springs (6011234) into the six holes of the two clamps from the groove side of the clamps.

REASON:

DRAWN BY:

ENG 37.3 1-64

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	Rev. 7/26/68 6/10/68
WStameris	MIT	30 July 68

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No. 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS-420-10001A-2
Sheet 2 of 2
ICRA NO: 10-260
Page 4 of 4
ICD NO. LIS-420-10001A
CCA NO. DATE
ICD TITLE
PGNS Installation Fixtures and Procedures

IDRR 36676 AUG 9 1968

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

4.3.12.2.3 Insert one shim (6011235) into each of the clamp grooves over the springs.

4.3.12.2.4 Insert one ring (6011237) into each of the clamp grooves over the shim.

4.3.12.3 Mount each clamp ass'y around the AOT flange and secure both halves together in position by inserting the four cap screws (NAS 1352C06LL 8) thru 6011875 clearance holes into the provided tapped holes in clamp 6011874 . Torque the four screws to 8 in/lbs +.5 in/lb. -.3 in/lb. insuring that gaps between clamp ass'ys are within 1/32" of each other at all times.

4.3.12.4 Apply loctite grade "CV" to the last full th'd of each screw (6011236). Tighten the six screws and torque to 10 in/lbs. ± 0.5 in/lbs.

4.3.12.5 Remove any excess loctite from threads and clamp, with tri-clorethylene.

NOTE: Sections 4.3.12.6 through 4.3.12.8 apply to LM-4 and subsequent only.

4.3.12.6 Wrap two (2) continuous layers of aluminum tape, 1008937-003, around the upper exposed periphery of the pressure seal flange and adjacent spacecraft.

4.3.12.7 Slide bellows assembly over pressure seal and align index line on bellows assembly with existing index line on pressure seal.

4.3.12.8 Mount bellows assembly to AOT using the eight screws removed in step 4.3.2.1. Torque all (12) twelve screws to 13.5 ± 0.5 inch pounds using the tightening sequences as shown on step 4.3.12.

REASON:

DRAWN BY:

ENG 37.3 1-64

REV	B
ICD NO.	LIS-490-10001

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

NAS 9-1100
Exhibit E
Para. 5.6.2
Line Item 13
Primary No. 697
Type II

INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J D Morris	GAEC	5/7/68
W.a. Stameris	MIT	17 May 68

PREPARED BY: J. Dalessandro/D. Meany

CHECKED: F. Hyatt F. Hyatt 5/7/68

TITLE: Weight Requirements for GFE/PGNCS Equipment MIT - GAEC

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER
	LTA-8, LM-1 thru LM-15				

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	SHEET 1 OF 5	LIS-490-10001	B

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
B		1	Replaced with new sheet 1 to provide for MIT approval. Removed NASA approval signature. Added vehicle effectivity.		GAEC	J D Morris	5/7/68
		4	Revised maximum weights for LGC and CDU. Revised total weight.		MIT	[illegible]	17 May 1968
	A-1	4	Revised LGC and CDU max. weights for LM-1				

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

SCOPE

This ICD defines the individual maximum weights of the PGNCS equipment furnished as GFE, and the GAEC units which mount on the GFE equipment. These individual maximum weights will be used for the design of the equipment support structure.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

PRIMARY GUIDANCE AND NAVIGATION SYSTEM MAXIMUM WEIGHTS

GFE SUPPLIED EQUIPMENT

ITEM	MAXIMUM WEIGHT PER LM (LBS)
1. Total GAEC Navigation Base mounted GFE equipment. This includes the following: a. Inertial Measurement Unit b. Harness Assembly "B" weight supported by the Navigation Base. c. Alignment Optical Telescope (including eyepieces) d. Alignment Optical Telescope Bellows Seal weight supported by the Navigation Base. e. GFE Navigation Base (NVB)	76.0
2. GAEC Structure mounted GFE equipment in the GAEC Navigation Base area. This includes the following: a. Structure supported Harness Assembly "B" weight b. Pulse Torque Assembly (PTA)	20.0
3. LM Guidance Computer (LGC)	75.0*
4. Coupling Data Unit (CDU)	40.0*
5. Power Servo Assembly/Signal Conditioner Assembly	27.0
6. Harness Assembly "A"	17.0
7. Display Keyboard (DSKY)	20.0
8. Computer Control and Reticle Dimmer (CCRD)	2.0

*For LM-1, LGC max. weight is 70.0 lbs, CDU max. weight is 37.7 lbs.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

PRIMARY GUIDANCE AND NAVIGATION SYSTEM MAXIMUM WEIGHTS

GAEC EQUIPMENT WHICH MOUNTS ON MIT EQUIPMENT

ITEM	MAXIMUM WEIGHT PER LM (LBS)
Abort Sensor Assembly (ASA) (includes the weight of the ASA cables supported by the GFE Navigation Base, the ASA coldplates and coolant.)	23.0

TDRR 36676 AUG [illegible] 1968

INTERFACE CONTROL DOCUMENT	SHEET 5 OF 5	ICD NO. LIS-490-10001	REV B

ENG 37.2 1-64

TDRR 34117 JUL 5 1967 TDRR [illegible]

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	[illegible]
W.a. Stameris	MIT/IL	6 June 1967
	MIT/IL	

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Exhibit E Para. 5.6.2
Line Item 13 Primary No. 697 Type II

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512
IRN NO: LIS 510-10001A-6
Sheet 1 of 1
ICRA NO: 10-228
Page 2 of 2
ICD NO. LIS 510-10001 A
CCA NO.
DATE 6/6/67
ICD TITLE
Thermodynamic Requirements of Guidance and Navigation Equipment.

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Add Paragraph 1.6 to ICD

1.6 Ground Cooling Requirements

Operating Mode	IMU Coolant Inlet Temp. °F	LGC Coolant Inlet Temp. °F	PTA Coolant Inlet Temp. °F	IMU Coolant Flow Rate lbs/hr	LGC Coolant Flow Rate lbs/hr	PTA Coolant Flow Rate lbs/hr	MAX Allowable Ambient & Struct. Temp.
IMU or LGC in Operate Mode	32 - 60	32 - 60	32 - 65	28 - 76	28 - 76	28 - 76	90°F*
IMU in Standby Mode, LGC in Standby Mode or Off	32 - 70	32 - 70	32 - 70	0 - 76	0 - 76	0 - 76	130°F

* For conditions where ambient or structure temperature exceeds 90°F mission cooling requirements apply.

VEHICLE EFFECTIVITY: ESI, LTA-1, 1R, 8, LM-1 AND SUBSEQUENT

REASON: Raise ground coolant inlet temperature & flow rate to avoid condensation

DRAWN BY: J. Rizzuto

GAC 37.3 1-66

TDRR 35136 NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	1/29/67
WStameris	MIT/IL	11 Nov 67

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NAS 9-1100 Line Item 13
Exhibit E Primary No. 697
Para. 5.6.2 Type II

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: LIS-520-10002A -1
Sheet 1 of 1

ICRA NO: 10-243
Page 2 of 2

ICD NO. LIS-520-10002A

CCA NO. DATE

ICD TITLE

Materials Compatibility Requirements - Grumman - MIT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

This IRN cancels ICD LIS-520-10002A.

REASON: Cancellation of ICD

DRAWN BY: J. Dalessandro

ENG 37.3 1-66

TDRR 34117 JUL 5 1967
[redacted]

AUTHORIZED SIGNATURES	REPRESENTING	DATE	INTERFACE REVISION NOTICE	CODE IDENT NO.	IRN NO: LIS-520-10001-6 Sheet 1 of 5
JJ Xlan	GAEC	6/1/67	INTERFACE CONTROL DOCUMENT	26512	ICRA NO: 10-225 Page 2 of 6
W. Stameris	MIT/IL	20 June 1967		ICD NO.	LIS-520-10001
			GRUMMAN AIRCRAFT ENGINEERING CORPORATION BETHPAGE, L. I., NEW YORK	CCA NO.	DATE
				ICD TITLE	LM Design Environment

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

Re: LIS-520-10001, dated 7/27/65 replace sheets 7, 8, 9, 10 of 18 with sheets 2, 3, 4, 5, of this IRN.

Note: This IRN supersedes the following IRN's to the degree specified.

IRN LIS 520-10001-1 (all changes to pp. 7 and 9)
IRN LIS 520-10001-2 (in its entirety)
IRN LIS 520-10001-3 (all changes to p. 8)
IRN LIS 520-10001-4 (all changes to p. 8)

Effectivity: LTA-1, LTA-3, LTA-5, LTA-8, LM-1 thru 15.

REASON: Insert latest LM vibration environment

DRAWN BY: J. Albanes

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

WS 6/20/67

These levels represent data from LTA-3 vibration tests. The levels are Design Limit levels mutually determined by GAEC and MSC ASPO in a data review summarized in LMM-520-4, 5, and 6.

Phase

C-1
(Launch and Boost)

Input to Equipment Supports (DSKY)

DSKY Vibration levels to be determined.

Input to Equipment Supports
(Use for IMU, AOT, NVB, CCRD, Wiring Harness "B", MIT/GAEC Navbase Interface)

Random 5 min/axis

X, Y, Z, Axes

20-100 cps	.005 g^2/cps
100-200	3 db/oct rise
200-1200	.01 g^2/cps
1200-1440	12 db/oct fall
1440-2000	.005 g^2/cps

Sinusoidal - 3 oct/min

X, Y, Z Axes

5-8 cps	.3 in DA
8-18	.154 in DA
18-100	1. g

1 sweep from 5 cps to 100 cps to 5 cps

Input to Equipment Supports (PTA)

Random - 5 min/axis

X, Y, Z Axes

20-100 cps	.005 g^2/cps
100-130	24 db/oct rise
130-300	.04 g^2/cps
300-500	12 db/oct fall
500-2000	.005 g^2/cps

Sinusoidal - 3 oct/min

X, Y, Z Axes

5-12 cps	.154 in DA
12-100	1.2 g

1 sweep from 5 cps to 100 cps to 5 cps

TDRR 34117 JUL 5 1967
[redacted]

IRN: LIS-520-10001-6
Sheet 2 of 5
ICRA: 10-225
Page 3 of 6

INTERFACE CONTROL DOCUMENT | SHEET 7 OF 18 | ICD NO. LIS-520-10001 | REV

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

WS 6/20/67

Input to Equipment Supports (CDU, PSA/SCA, Wiring Harness "A")

Random - 5 min/axis

X, Z, Axis		Y Axis	
20-36 cps	.005 g^2/cps	20-36 cps	.005 g^2/cps
36-100	3 db/oct rise	36-100	3 db/oct rise
100-225	.015 g^2/cps	100-350	.015 g^2/cps
225-400	12 db/oct rise	350-500	12 db/oct rise
400-550	.15 g^2/cps	500-800	.06 g^2/cps
550-740	24 db/oct fall	800-1000	12 db/oct rise
740-1200	.015 g^2/cps	1000-1300	.15 g^2/cps
1200-1600	12 db/oct fall	1300-2000	24 db/oct fall
1600-2000	.005 g^2/cps		

Sinusoidal - 3 oct/min

X, Y, Z, Axes

5-15.5 cps	.154 in DA
15.5-100	1.9 g

1 sweep from 5 cps to 100 cps to 5 cps

Input to Equipment Supports (LGC)

Random - 5 min/axis

X, Y, Z Axes

20-62 cps	.005 g^2/cps
62-100	3 db/oct rise
100-2000	.008 g^2/cps

Sinusoidal - 3 oct/min

X, Y, Z Axes

5-11.5 cps	.154 in DA
11.5-100	1 g

1 sweep from 5 cps to 100 cps to 5 cps

Phase

C-2
(Lunar Ascent and Descent)

Input to CCRD

Random - 21 min/axis

X, Y, Z Axes

10-20 cps	12 db/oct rise
20-100	.02 g^2/cps
100-120	12 db/oct fall
120-2000	.01 g^2/cps

Sinusoidal-1/2 oct/min

X, Y, Z Axes

5-17 cps	.1 in DA
17-100	1.54 g

1 sweep from 5 to 100 to 5 cps

TDRR 34117 JUL 5 1967
[redacted]

IRN: LIS-520-10001-6
Sheet 2 of 5
ICRA: 10-225
Page 4 of 6

INTERFACE CONTROL DOCUMENT | SHEET 8 OF 18 | ICD NO. LIS-520-10001 | REV

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

WS 6/20/67

IMU, AOT, Wiring Harness B Environment (MIT/GAEC NAVBASE Interface)

Linear Random Vibration - 7 min/axis		14 min/axis	
10-22.5 cps	12 db/oct rise	10-22.5 cps	12 db/oct rise
22.5-35	.0006 g^2/cps	22.5-35	.0006 g^2/cps
35-60	9 db/oct rise	35-44	9 db/oct rise
60-70	.003 g^2/cps	44-82	.0012 g^2/cps
70-95	24 db/oct fall	82-95	24 db/oct fall
95-700	.0004 g^2/cps	95-700	.0004 g^2/cps
700-2000	3 db/oct fall	700-2000	3 db/oct fall

Sinusoidal - None

Rotational Random Vibration

Rotation about X Axis

(7 minutes)	10-20 cps	10^{-2}	(rad/sec^2) ^{2}/cps
	50-70	1.6	"
	100-150	0.1	"
	250-400	2.5	"
(14 minutes)	10-20 cps	10^{-2}	(rad/sec^2) ^{2}/cps
	32-60	1/5 x 10^{-1}	"
	90-2000	10^{-2}	"

Rotation about Y Axis

(7 minutes)	10-20 cps	10^{-2}	(rad/sec^2) ^{2}/cps
	40-70	1.8	"
	100-2000	10^{-2}	"
(14 minutes)	10-20	10^{-2}	"
	38-56	1.3	"
	80-2000	10^{-2}	"

Rotation about Z Axis

(7 minutes)	10-20 cps	10^{-2}	"
	50-60	4	"
	100-2000	10^{-2}	"
(14 minutes)	10-20	10^{-2}	"
	42-60	1.5	"
	90-2000	10^{-2}	"

TDRR 34117 JUL 5 1967
[redacted]

NOTE: Plot straight line between levels on log-log paper.

IRN: LIS-520-10001-6
Sheet 4 of 5
ICRA: 10-225
Page 5 of 6

INTERFACE CONTROL DOCUMENT | SHEET 9 OF 18 | ICD NO. LIS-520-10001 | REV

ENG 37.3 1-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

We, 6/20/67

Input for LGC, CDU, PSA/SCA Wiring Harness A, PTA

Random - 21 min/axis

10-20 cps	12 db/oct rise
20-100	.01 g^2/cps
100-120	12 db/oct fall
120-2000	.005 g^2/cps

Sine - 1/2 oct/min

5-30 cps	.03 in D^A
30-100	1.4 g

Input for DSKY - DSKY Vibration Levels to be determined.

During the launch and boost phase of flight the LM is exposed to random vibration of varied levels and spectra for 17 minutes. During all but approximately 2.5 minutes of this period, the intensity of the random vibration is of such a low level that it is considered to be of negligible design significance. In addition, the launch and boost environment is considered to include peak vibration levels which are represented by the above sinusoidal vibration envelopes. The number of sinusoidal peaks for design may be considered to be 1 percent of the natural frequency of the equipment and its supporting structure times the number of seconds exposure. For design purposes, the above random spectrum and sinusoidal levels applied separately for 5 minutes along each of the three mutually perpendicular axes X, Y, and Z are considered to adequately represent the vibration environment. The above IMU, AOT, NVB, CCRD and wiring harness"B" environments are specified at the GAEC/MIT Navbase interface (LM coordinate axes X = +310.5, Y= -6, Z= +57.0). The GAEC navigation base is defined by GAEC drawing No. LDW-280-28066 "Frame Installation Ascent Stage-Cabin Navigation Base Support" approved 12/1/65. The design environment of the CCRD should include vibration levels equivalent to those seen by a single-degree-of-freedom system with an amplification factor of 15, at the resonant frequency, and excited by the LM IMU AOT levels as specified on Pages 7 and 8 of the ICD. All other equipment is effectively mounted on primary structure.

During lunar descent and ascent phases of flight the LM is exposed to random vibration of varied levels and spectra for 21 minutes. In addition, the environment is considered to include peak vibration levels which are represented by the above sinusoidal vibration envelopes. The number of sinusoidal peaks for design may be considered to be 1 percent of the natural frequency of the equipment and its supporting structure times the number of seconds of exposure. For design purposes, the above random spectrum and sinusoidal levels applied separately for 21 minutes along each of the three mutually perpendicular axes, X, Y, and Z are considered to adequately represent the vibration environment.

The IMU, AOT, LGC, CDU, PSA/SCA, and PTA Ascent/Descent environment is the response of the support structure of the above equipment on LTA-3 when a design limit oscillatory thrust from the ascent, descent, and RCS engine was applied to the LM vehicle. These levels should be used to evaluate both performance and structural integrity.

TDRR 3 4 1 1 7 JUL 5 1967

[redacted]

IRN: LIS-520-10001-6
Sheet 5 of 5
ICRA, 10-7.25
Page 6 of 6

INTERFACE CONTROL DOCUMENT	SHEET 10 OF 18	ICD NO. LIS-520-10001	REV

ENG 37.2 1-64

TDRR 3513C NOV 21 1967

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GAEC	8/2/67
W. Stameris	MIT 16 Nov	1967

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

CODE IDENT NO. 26512

IRN NO: Sheet 1 of 1
LIS 540-10001-18

ICRA NO: 10-241
Sheet 2 of 6

ICD NO. LIS 540-10001

CCA NO. DATE

ICD TITLE
LM-PGNCS Functional Interface Requirements

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

DESCRIPTION:

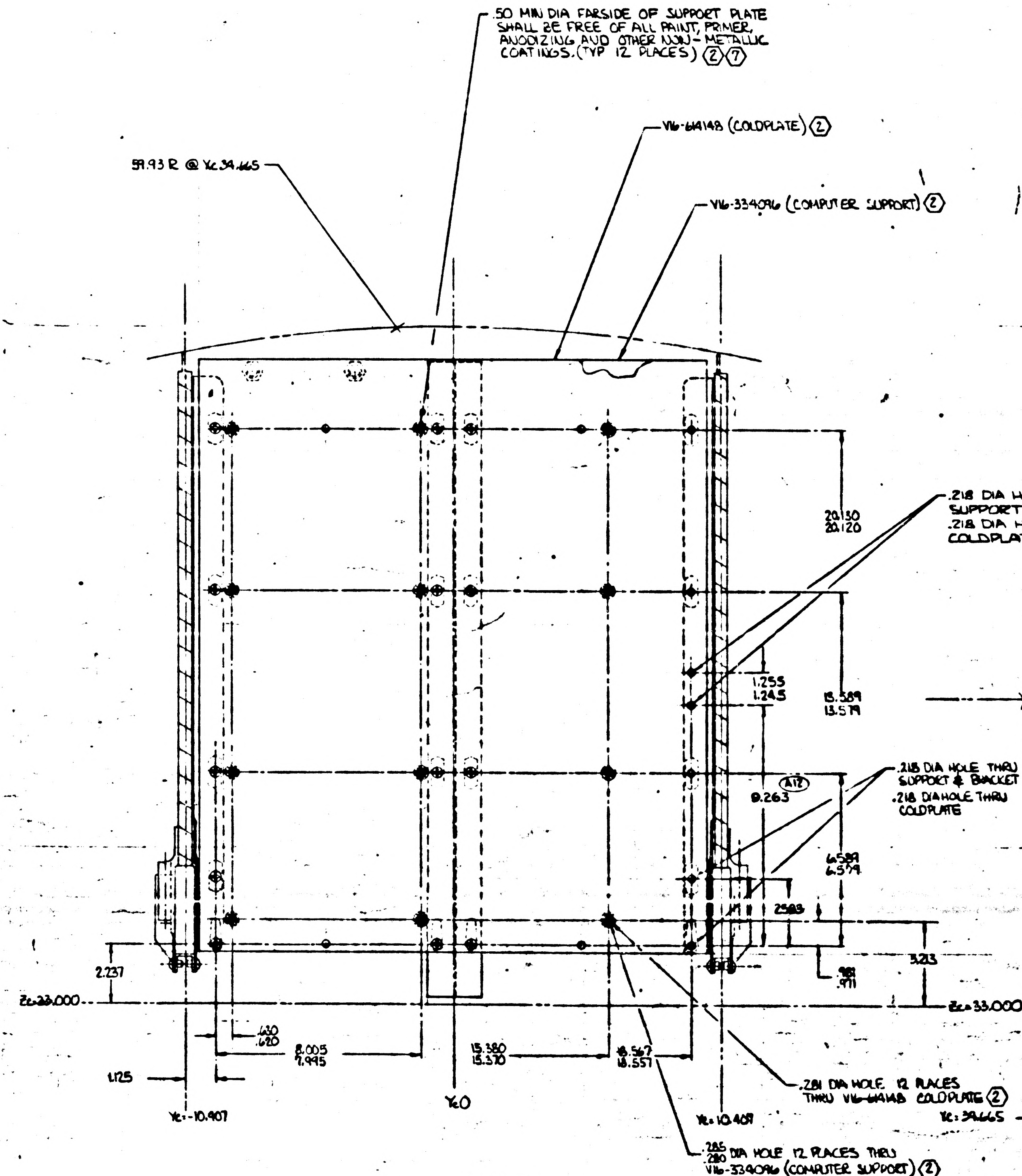
Add the following to Section 1.2.5:

In LM-1, the IMU cage switch is disconnected so manual caging is not possible.

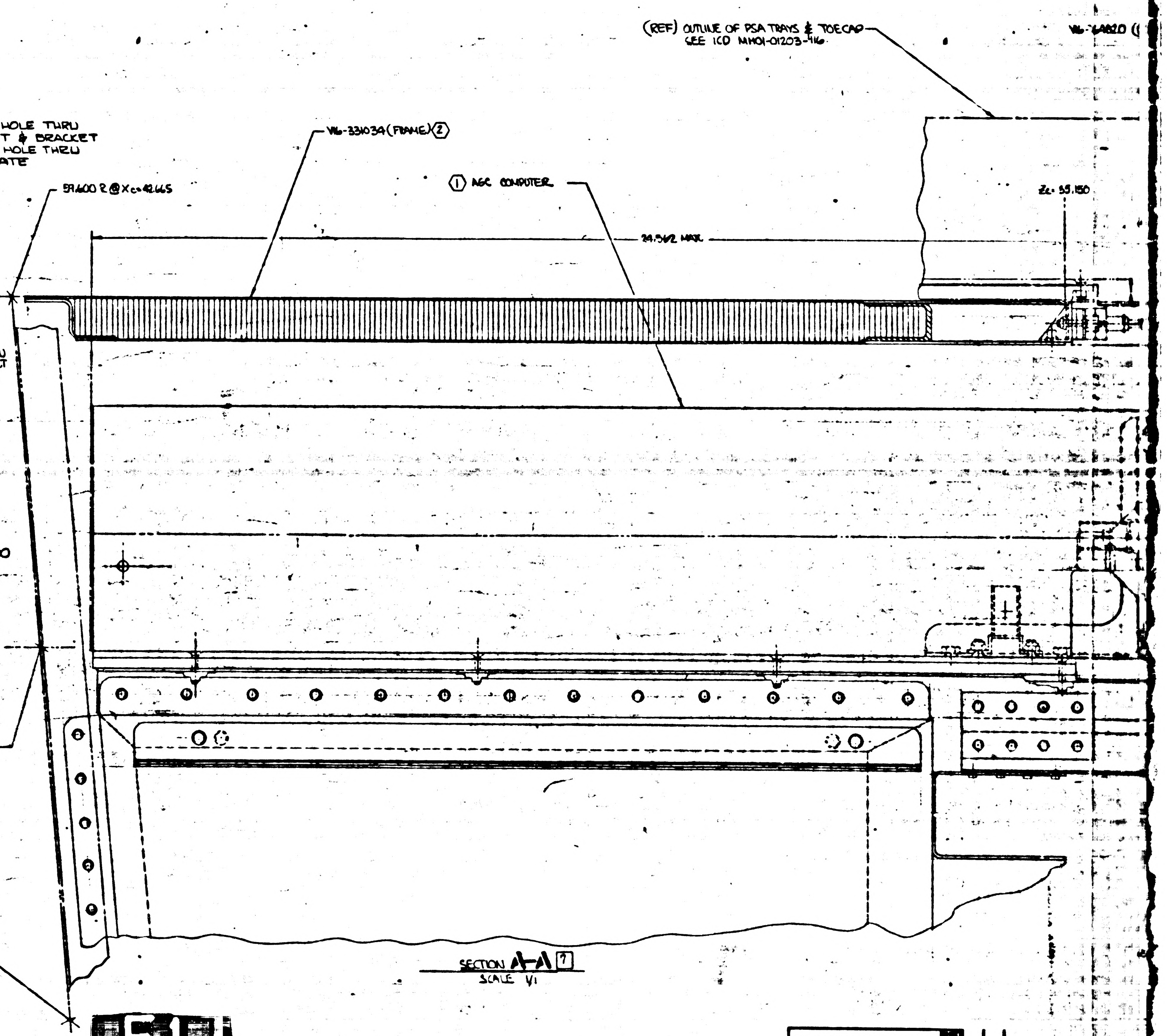
REASON: IMU Cage Switch Disconnected in LM-1

DRAWN BY: R. Kerr

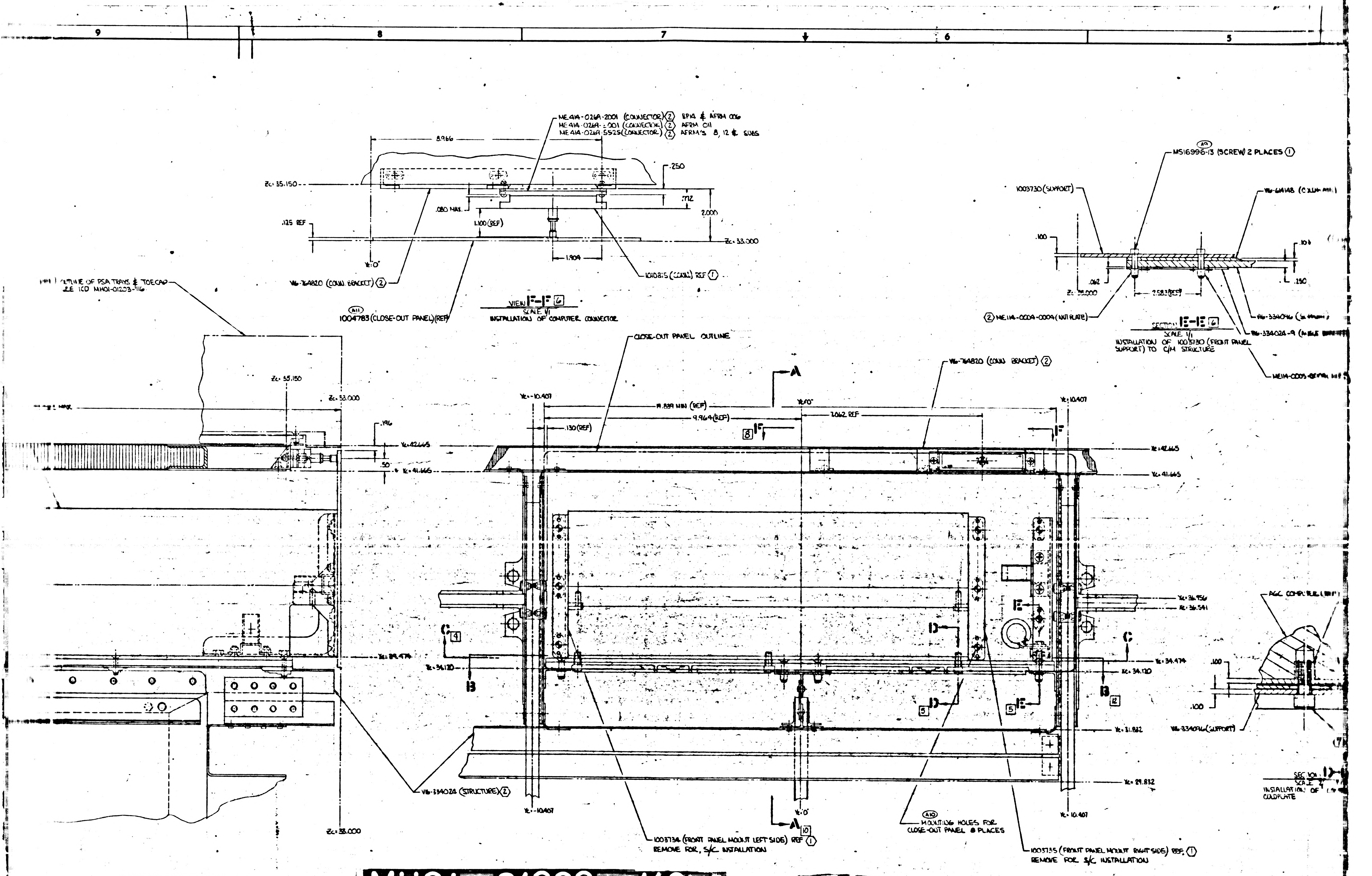
ENG 37.3 1-66

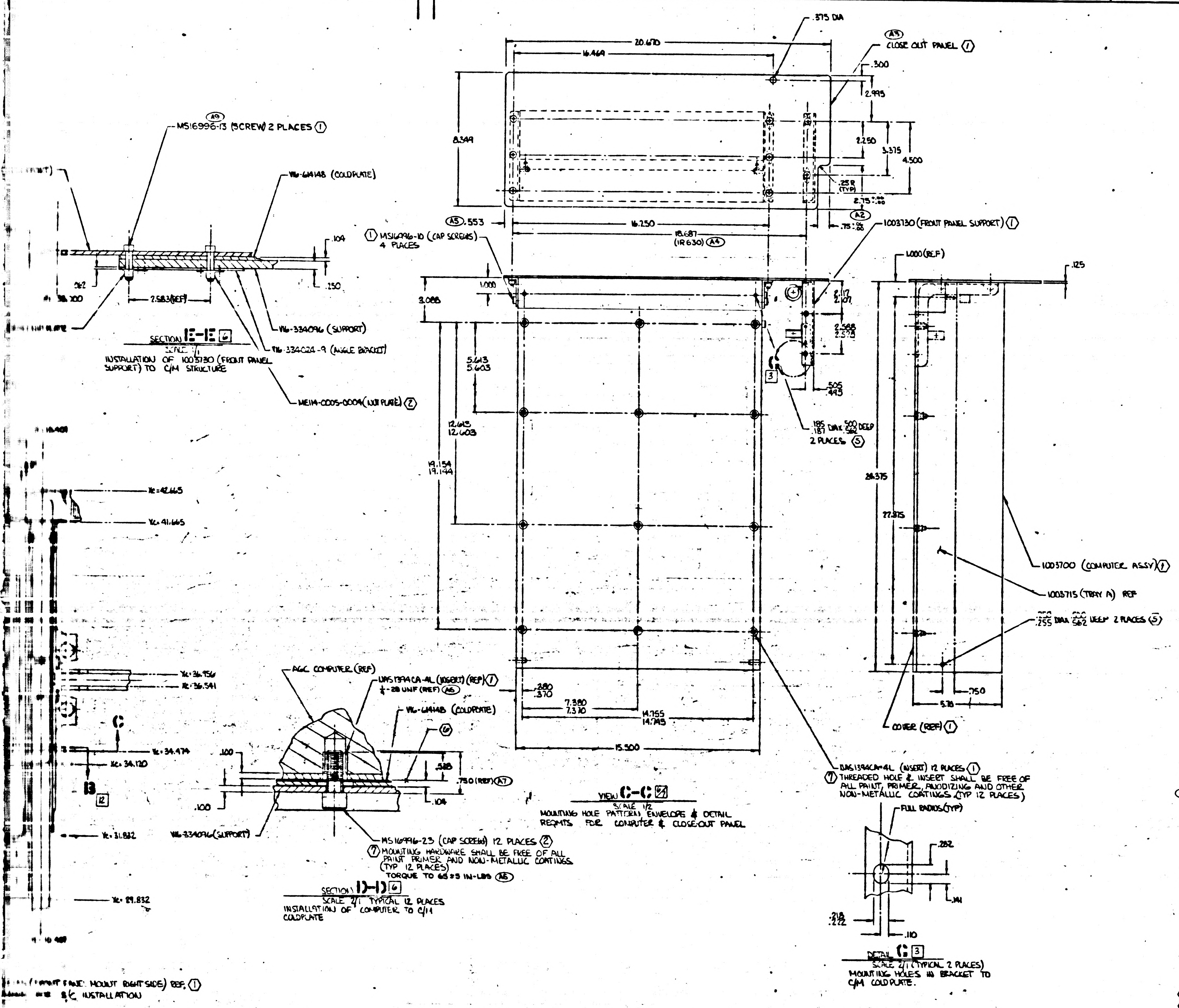

.50 MIN DIA FARSIDE OF SUPPORT PLATE SHALL BE FREE OF ALL PAINT, PRIMER, ANODIZING AND OTHER NON-METALLIC COATINGS. (TYP 12 PLACES) ⟨2⟩⟨7⟩
V16-614148 (COLDPLATE) ⟨2⟩
59.93 R @ Xc 34.665
V16-334096 (COMPUTER SUPPORT) ⟨2⟩
.218 DIA HOLE THRU SUPPORT & BRACKET .218 DIA HOLE THRU COLDPLATE
20.130
20.120
1.255
1.245
13.589
13.579
.218 DIA HOLE THRU SUPPORT & BRACKET .218 DIA HOLE THRU COLDPLATE
A12
9.263
6.589
6.579
2.583
3.213
.981
.971
2.237
Zc 33.000
Zc 33.000
.630
.620
8.005
7.995
15.380
15.370
18.567
18.557
1.125
Yc -10.907
Yc 0
Yc 10.409
.281 DIA HOLE 12 PLACES THRU V16-614148 COLDPLATE ⟨2⟩
.285
.280 DIA HOLE 12 PLACES THRU V16-334096 (COMPUTER SUPPORT) ⟨2⟩

VIEW **13-13** 6/7
SCALE 1/2
HOLE PATTERN FOR COMPUTER ASSY
IN C/M STRUCTURE


(REF) OUTLINE OF PSA TRAYS & TOECAP SEE ICD MH01-01203-116
V16-614820 (
Zc 35.150
.125 RE
V16-331034 (FRAME) ⟨2⟩
① AGC COMPUTER
59.600 R @ Xc 42.665
Zc 35.150
24.562 MAX
Yc 39.665
59.93 R @ Xc 34.665 @ Yc 0
INNER ML

SECTION **A-A** 7
SCALE 1/1


9
8
7
6
5
ME414-0269-2001 (CONNECTOR) ⟨2⟩ BP14 & AFRM 006
ME414-0269-_001 (CONNECTOR) ⟨2⟩ AFRM 011
ME414-0269-5525 (CONNECTOR) ⟨2⟩ AFRM'S 8, 12 & SUBS
8.966
.250
Zc=35.150
.712
2.000
.080 MAX.
1.100 (REF)
.125 REF
Zc=33.000
1.904
Yc=0°
V16-764820 (CONN. BRACKET) ⟨2⟩
1010815 (CONN) REF ⟨1⟩
A11
1004783 (CLOSE-OUT PANEL) (REF)
VIEW F-F 6
SCALE 1/1
INSTALLATION OF COMPUTER CONNECTOR
A9
MS16996-13 (SCREW) 2 PLACES ⟨1⟩
1003730 (SUPPORT)
V16-614148 (C
.100
.106
.250
.062
Zc=33.000
2.583 (REF)
⟨2⟩ ME114-0004-0004 (NUT PLATE)
SECTION E-E 6
SCALE 1/1
INSTALLATION OF 1003730 (FRONT PANEL SUPPORT) TO C/M STRUCTURE
V16-334046 (S
V16-334024-9 (
ME114-0005-
MH1 OUTLINE OF PSA TRAYS & TOECAP SEE ICD MH01-01203-116
CLOSE-OUT PANEL OUTLINE
V16-764820 (CONN BRACKET) ⟨2⟩
A
Zc=35.150
Zc=33.000
MAX
.196
.50
Yc=42.665
Yc=41.665
Yc=-10.407
11.839 MIN (REF)
9.964 (REF)
Yc=0°
7.062 REF
.130 (REF)
8 F
F
Yc=10.407
Yc=42.665
Yc=41.665
E
Yc=36.956
Yc=36.541
AGC COMPUTER (
C 4
D
C
Yc=34.474
Yc=34.474
Yc=34.120
Yc=34.120
B
B 12
5 D
5 E
.100
.100
V16-334046 (SUPPORT)
Yc=31.832
Yc=29.832
V16-334024 (STRUCTURE) ⟨2⟩
Yc=-10.407
Zc=33.000
Yc=0°
A 10
Yc=10.407
SECTION D-D
SCALE
INSTALLATION OF
COLDPLATE
1003734 (FRONT PANEL MOUNT LEFT SIDE) REF ⟨1⟩
REMOVE FOR, S/C INSTALLATION
A10
MOUNTING HOLES FOR CLOSE-OUT PANEL 8 PLACES
1003735 (FRONT PANEL MOUNT RIGHT SIDE) REF. ⟨1⟩
REMOVE FOR S/C INSTALLATION


5
4
3
2
1
.375 DIA
A3
CLOSE OUT PANEL ①
20.670
16.469
.300
2.995
8.349
2.250
3.375
4.500
.25 R (TYP)
2.75 +.06 -.00
A2
A5 .553
16.250
18.687 (1R630) A4
.75 +.06 -.00
① MS16996-10 (CAP SCREWS) 4 PLACES
1003730 (FRONT PANEL SUPPORT) ①
1.000 (REF)
.125
1.000
3.088
2.17 2.07
2.588 2.578
5.613 5.603
3
.505 .495
.185 .187 DIA .500 .562 DEEP 2 PLACES ⑤
12.613 12.603
19.154 19.144
28.375
27.375
1003700 (COMPUTER ASSY) ①
1003715 (TRAY A) REF
.255 DIA .562 DEEP 2 PLACES ⑤
.380 .370
7.380 7.370
14.755 14.745
15.500
.750
5.78
COVER (REF) ①
A9
MS16996-13 (SCREW) 2 PLACES ①
V16-614148 (COLDPLATE)
.104
.062
.250
2.583 (REF)
V16-334096 (SUPPORT)
V16-334024-9 (ANGLE BRACKET)
ME114-0005-0004 (NUT PLATE) ②
SECTION E-E 6
SCALE 1/1
INSTALLATION OF 1003730 (FRONT PANEL SUPPORT) TO C/M STRUCTURE
Xc=42.665
Xc=41.665
Xc=36.956
Xc=36.541
C
Xc=34.474
Xc=34.120
B 12
Xc=31.832
Xc=29.832
(FRONT PANEL MOUNT RIGHT SIDE) REF ①
℄ INSTALLATION
AGC COMPUTER (REF)
NAS1394CA-4L (INSERT) (REF) ①
1/4-28 UNF (REF) A6
V16-614148 (COLDPLATE)
⑥
.100
.528
.750 (REF) A7
.104
.100
V16-334096 (SUPPORT)
MS16996-23 (CAP SCREW) 12 PLACES ②
⑦ MOUNTING HARDWARE SHALL BE FREE OF ALL PAINT PRIMER AND NON-METALLIC COATINGS (TYP 12 PLACES)
TORQUE TO 65±5 IN-LBS A6
SECTION D-D 6
SCALE 2/1 TYPICAL 12 PLACES
INSTALLATION OF COMPUTER TO C/M COLDPLATE
VIEW C-C 6
SCALE 1/2
MOUNTING HOLE PATTERN ENVELOPE & DETAIL REQMTS FOR COMPUTER & CLOSE-OUT PANEL
NAS1394CA-4L (INSERT) 12 PLACES ①
⑦ THREADED HOLE & INSERT SHALL BE FREE OF ALL PAINT, PRIMER, ANODIZING AND OTHER NON-METALLIC COATINGS (TYP 12 PLACES)
FULL RADIUS (TYP)
.282
.141
.218 .222
.110
DETAIL G 3
SCALE 2/1 (TYPICAL 2 PLACES)
MOUNTING HOLES IN BRACKET TO C/M COLDPLATE.

12. PART NUMBERS ARE FOR REFERENCE ONLY.

⑤ 11. HOLES FOR GSE HANDLING EQUIPMENT.

A1 10.

9. MATL & FINISH AT MECHANICAL INTERFACE
- A. CLOSE-OUT PANEL SUPPORT: 6061-T6 AL PER QQ-A-250/11 T6, PLATE (ELECTRODEPOSITED) PER QQ-C-320 CLASS 2, TYPE II
- B. AGC COMPUTER: AL ALLOY 6061 T6 PER QQ-A-250/11 T6, PLATE (ELECTRODEPOSITED) PER QQ-320 CLASS 2, TYPE II
- C. COMPUTER COLDPLATE: AL SHEET 5052-0, QQ-A-250/8, INDENTATION & SCRATCHES NOT EXCEEDING .003 IN DEPTH & .300 WIDTH

8. FOR CONNECTORS & CABLING INFORMATION SEE MH01-01206-116

⑦ 7. BONDING—DC RESISTANCE ACROSS MATED METALLIC SURFACES SHALL BE 10 MILLIOHMS OR LESS. PROTECTION OF BARE METAL SURFACES — BARE METAL SURFACES SHALL BE TEMPORARILY PROTECTED BY APPLYING A COAT OF MIL-C-16173 GRADE 4. CORROSION PREVENTIVE COMPOUND. ALUMINUM SURFACES TREATED PER MIL-C-5541 WITH IRIDITE 14-2 OR ALODINE 1200S NEEDS NO OTHER PROTECTION.

⑥ 6. INTERFACE SURFACE FINISH BETWEEN COMPUTER & COLDPLATE TO BE 32 MICROINCHES

5. ALL REFERENCES TO X Y & Z ARE THEORETICAL LOCATIONS FOR PURPOSES OF ORIENTATION

③ 4. DESIGN DATA REQUIRED

② 3. NORTH AMERICAN AVIATION INC. SPACE & INFORMATION SYSTEMS DIVISION, DOWNEY CALIF (NAA-S&ID)

① 2. MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS. (MIT)

1. THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN.

NOTES: UNLESS OTHERWISE SPECIFIED.

MODEL NO	PART NO	DESCRIPTION
		EFFECTIVITY AND
		INTERFACE CONTROL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:

DECIMALS	ANGLES
.XX = ± .03	
.XXX = ± .010	± 30'

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

DO NOT SCALE

DR. BY	F.M. Duncan	1-11-65
CHK BY	E.W. Beattie	1-11-65
AUTH SIGNATURE	REP	DATE
	NAA	
	MIT	

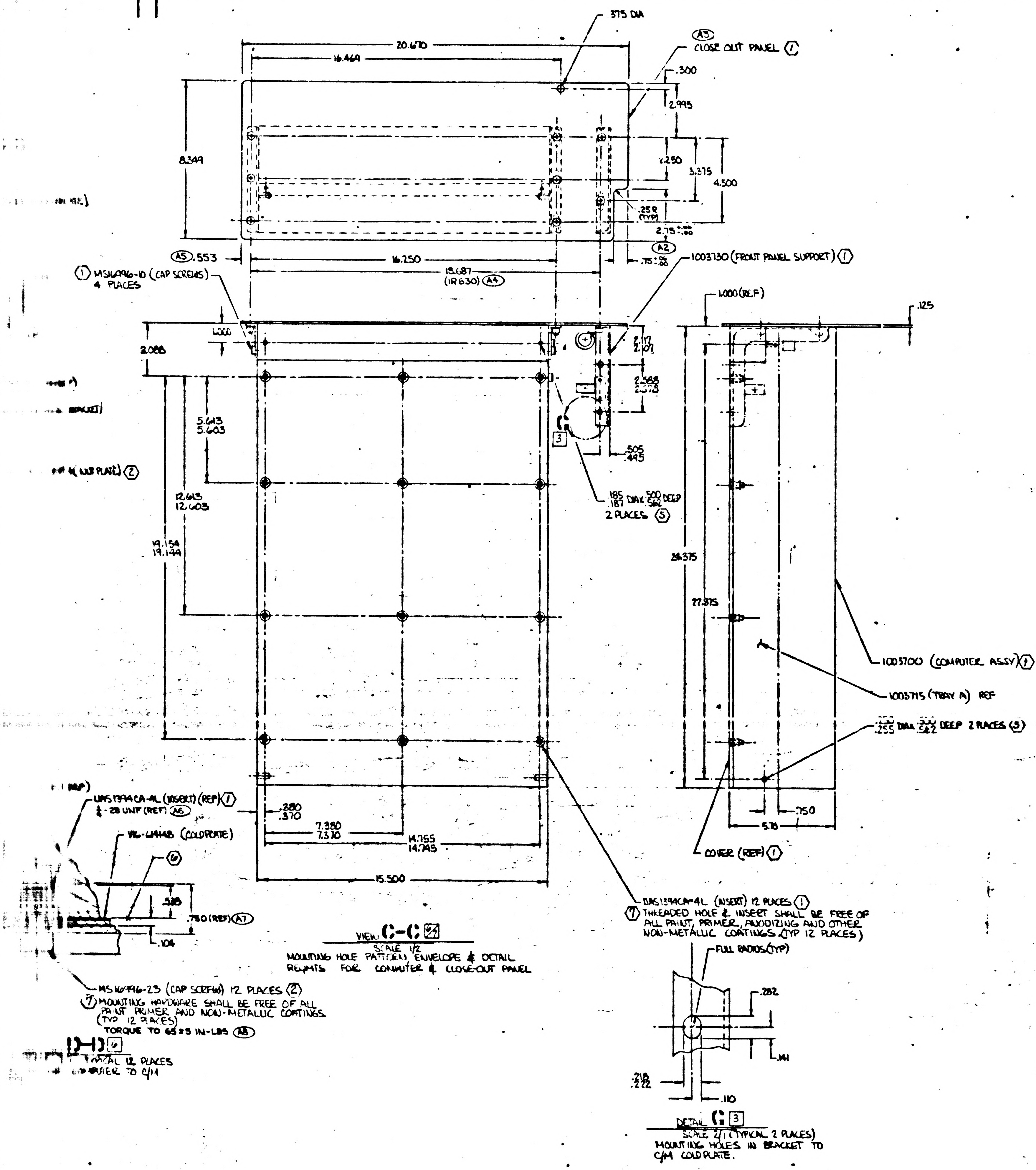
MH01-01202-116 1

MH01-01202-116 F3

SYM	ZONE	DESCRIPTION	REQD BY	REP	DATE	APPROVED
A	G/H	1. DELETED G/A, °0: COMMAND MODULE 8, 11, 12, 14, 17 & 20				
	5	2. ADDED 2.75 +.06 -.00 X .75 +.06 -.00 CUTOUT				
	3	3. 1004783 WAS 1004285				
	4	4. 18.687 (IRN 630) WAS 19.437	IRN 630			
	4	5. .553 WAS .512				
	4	6. ADDED: ¼-28 UNF (REF)				
	4-5	7. ADDED: .750 (REF)				
	4-5	8. ADDED: TORQUE TO 65±5 IN LBS				
	5	9. MS16996-13 (SCREW) 2 PLACES ⟨1⟩ WAS NAS1003-5 (BOLT) 2 PLACES ⟨2⟩				
	6	10. MOUNTING HOLES FOR CLOSE-OUT PANEL (8 PLACES) WAS MIT MOUNTING HOLES FOR CLOSE-OUT PANEL 1004285 ⟨1⟩		MIT NAA	4-5-66 Z.M.H.	
	8	11. 1004783 WAS 1004285		MIT		
	11	12. 9.263 WAS 10.523-10.503	IRN 0004			

TDRR 29653 JUN 14 1968

(resubmitted Aug 30, 1968 – original sepia missing)



4
3
2
1
.375 DIA
(A3) CLOSE OUT PANEL ⟨1⟩
20.670
16.469
.300
2.995
8.349
.250
3.375
4.500
.25R (TYP)
2.75 +.06 -.00
(A2)
(A5) .553
16.250
18.687 (IR630) (A4)
.75 +.06 -.00
1003730 (FRONT PANEL SUPPORT) ⟨1⟩
⟨1⟩ MS16996-10 (CAP SCREWS) 4 PLACES
1.000 (REF)
.125
1.000
2.088
2.117
2.107
2.588
2.578
5.613
5.603
3
.505
.495
12.613
12.603
.185
.187 DIA .500 .562 DEEP 2 PLACES ⟨5⟩
19.154
19.144
24.375
22.375
1003700 (COMPUTER ASSY) ⟨1⟩
1003715 (TRAY A) REF
.255 .255 DIA .500 .562 DEEP 2 PLACES ⟨5⟩
NAS1394CA-4L (INSERT) (REF) ⟨1⟩
¼-28 UNF (REF) (A6)
.380
.370
7.380
7.370
14.755
14.745
15.500
.750
5.70
COVER (REF) ⟨1⟩
ML-6414B (COLDPLATE)
⟨6⟩
.538
.750 (REF) (A7)
.104
VIEW C-C
SCALE 1/2
MOUNTING HOLE PATTERN, ENVELOPE & DETAIL REQMTS FOR COMPUTER & CLOSE-OUT PANEL
MS16996-23 (CAP SCREW) 12 PLACES ⟨2⟩
⟨7⟩ MOUNTING HARDWARE SHALL BE FREE OF ALL PAINT PRIMER AND NON-METALLIC COATINGS (TYP 12 PLACES)
TORQUE TO 65±5 IN-LBS (A8)
D-D 6
TYPICAL 12 PLACES
COMPUTER TO C/M
NAS1394CA-4L (INSERT) 12 PLACES ⟨1⟩
⟨7⟩ THREADED HOLE & INSERT SHALL BE FREE OF ALL PAINT, PRIMER, ANODIZING AND OTHER NON-METALLIC COATINGS (TYP 12 PLACES)
FULL RADIUS (TYP)
.282
.141
.218
.222
.110
DETAIL C 3
SCALE 2/1 (TYPICAL 2 PLACES)
MOUNTING HOLES IN BRACKET TO C/M COLDPLATE.

12. PART NUMBERS ARE FOR REFERENCE ONLY.

⑤ 11. HOLES FOR GSE HANDLING EQUIPMENT.

(A1) 10.

9. MATL & FINISH AT MECHANICAL INTERFACE

A. CLOSE-OUT PANEL SUPPORT: 6061-T6 AL PER QQ-A-250/11 T6, PLATE (ELECTROLESS NICKEL) PER QQ-C-320 CLASS 2, TYPE II

B. AGC COMPUTER: AL ALLOY 6061 T6 PER QQ-A-250/11 T6, PLATE (ELECTRODEPOSITED) PER QQ-320 CLASS 2 TYPE II

COMPUTER COLDPLATE: AL SHEET 5052-0 QQ-A-250/8, ANODIZATION & SURFACES NOT EXCEEDING .003 IN DEPTH & .300 WIDE

8. FOR CONNECTORS & CABLING INFORMATION SEE MH01-01206-116

⑦ 7. BONDING – DC RESISTANCE ACROSS MATED METALLIC SURFACES SHALL BE 10 MILLIOHMS OR LESS. PROTECTION OF BARE METAL SURFACES – BARE METAL SURFACES SHALL BE TEMPORARILY PROTECTED BY APPLYING A COAT OF MIL-C-16173 GRADE 4, CORROSION PREVENTIVE COMPOUND. ALUMINUM SURFACES TREATED PER MIL-C-5541 WITH IRIDITE 14-2 OR ALODINE 1200S NEEDS NO OTHER PROTECTION.

⑥ 6. INTERFACE SURFACE FINISH BETWEEN COMPUTER & COLDPLATE TO BE 32 MICROINCHES

5. ALL REFERENCES TO X, Y & Z ARE THEORETICAL LOCATIONS FOR PURPOSES OF ORIENTATION.

③ 4. DESIGN DATA REQUIRED

② 3. NORTH AMERICAN AVIATION INC., SPACE & INFORMATION SYSTEMS DIVISION, DOWNEY CALIF (NAA-S&ID)

① 2. MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS. (MIT)

1. THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN.

NOTES: UNLESS OTHERWISE SPECIFIED.

MODEL NO	PART NO	DESCRIPTION	APPLICABLE SPECIFICATIONS

EFFECTIVITY AND SPECIFICATIONS

INTERFACE CONTROL DOCUMENT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
DECIMALS .XX = ± .03 .XXX = ± .010
ANGLES ± 30'

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

DR BY	T.M. Vaughan	1-10-65
CHK BY	E.W. Battle	1-11-65
AUTH SIGNATURE	REP	DATE
Joseph L.	NAA	6-4-6
	MIT	

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD DOWNEY CALIFORNIA

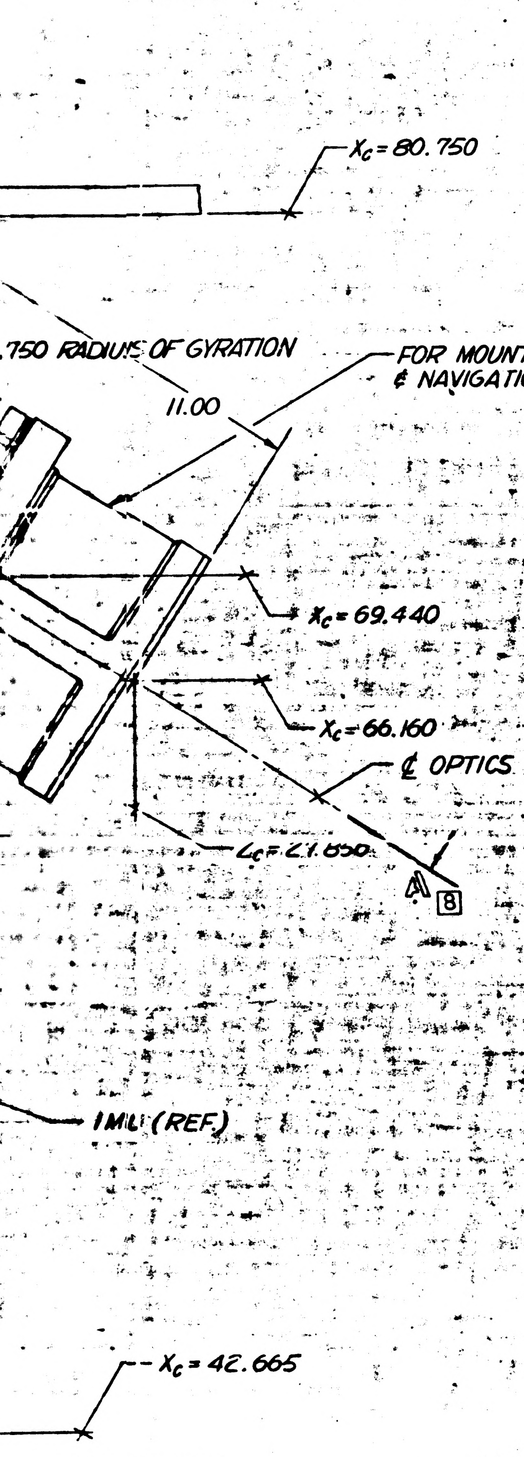
BLK I SERIES 100 AGC TO C/M-LWR EQUIP BAY STRUCTURE, MIT-S&ID NAA.

CODE IDENT NO	SIZE	
03953	J	MH01-01202-116

F4

22A

REVISIONS						
SYM	ZONE	DESCRIPTION	REQD BY	REP	DATE	APPROVED
		[illegible] 21371 [illegible] AUG 6 [illegible]				



X_c = 80.750
.750 RADIUS OF GYRATION
11.00
FOR MOUNTING OF SEXTANT, TELESCOPE & NAVIGATIONAL BASE SEE MH01-01201-116
X_c = 69.440
X_c = 66.160
℄ OPTICS
Z_c = 21.850
A 8
IMU (REF.)
X_c = 42.665
Z_c = 35.000

NOTES: UNLESS OTHERWISE SPECIFIED

1. THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN.
① 2. NORTH AMERICAN AVIATION INC., SPACE & INFORMATION SYSTEMS DIVISION, DOWNEY, CALIF.
② 3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.
4. ALL REFERENCES TO X, Y & Z ARE THEORETICAL LOCATIONS FOR PURPOSES OF ORIENTATION.
5. SPACECRAFTS 6, 8, 11, 12, 14, 17 & 20.

MODEL NO.	PART NO.	DESCRIPTION	APPLICABLE SPECIFICATIONS

EFFECTIVITY AND SPECIFICATIONS

INTERFACE CONTROL DOCUMENT

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS ANGLES
.XX = ± .03
.XXX = ± .010 ± 30'

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED.

DO NOT SCALE

DR BY	P.H. Duncan	4-16-65
CHK BY		
AUTH SIGNATURE	REP	DATE
Toddy	NAA	5-19-65
	MIT	4/23/65

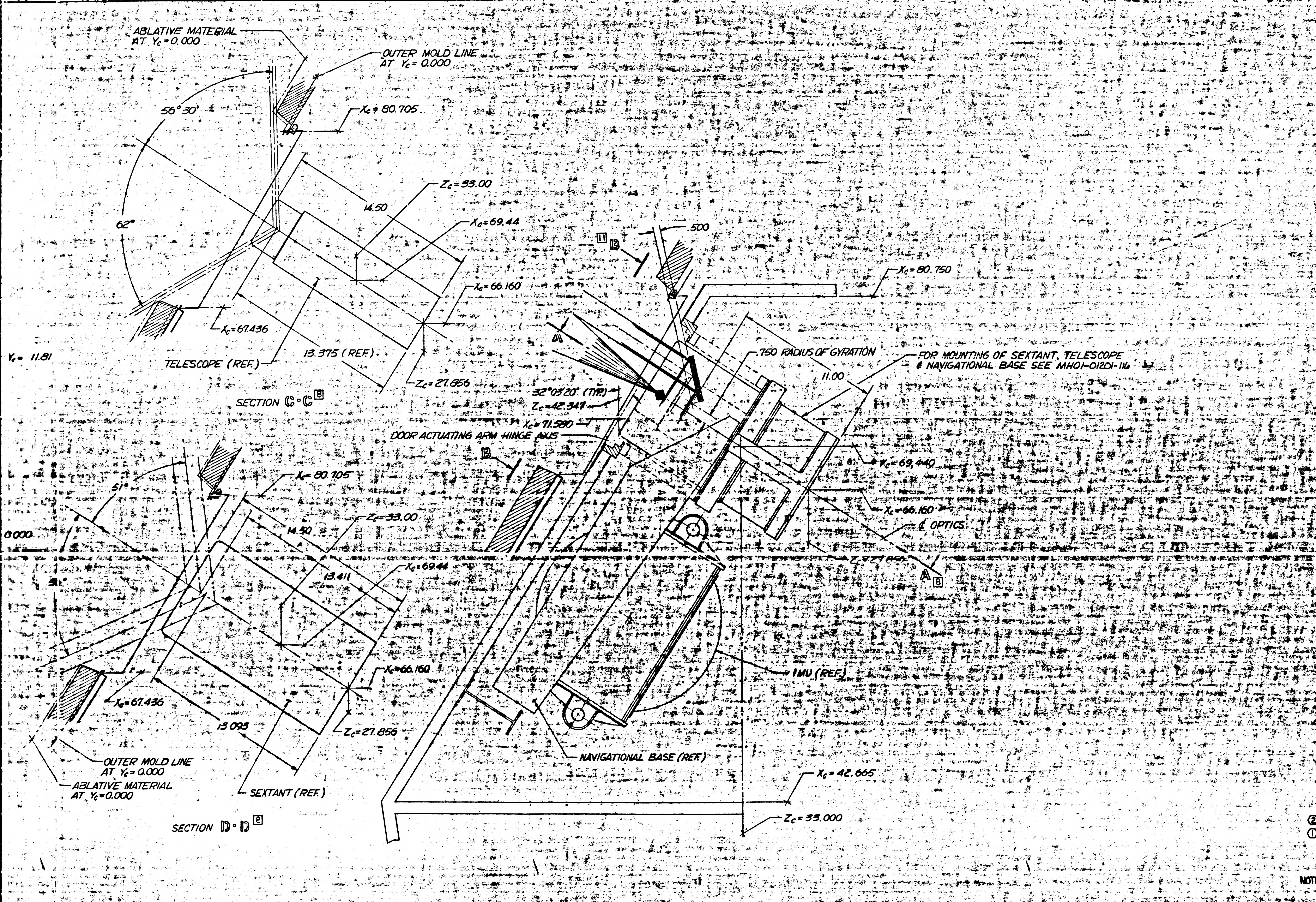
NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

OPTICAL FIELD OF VIEW
INSTALLED

CODE IDENT NO. 03953
SIZE J
MH01-01215-116
SCALE 1/2
SHEET 1 OF 1

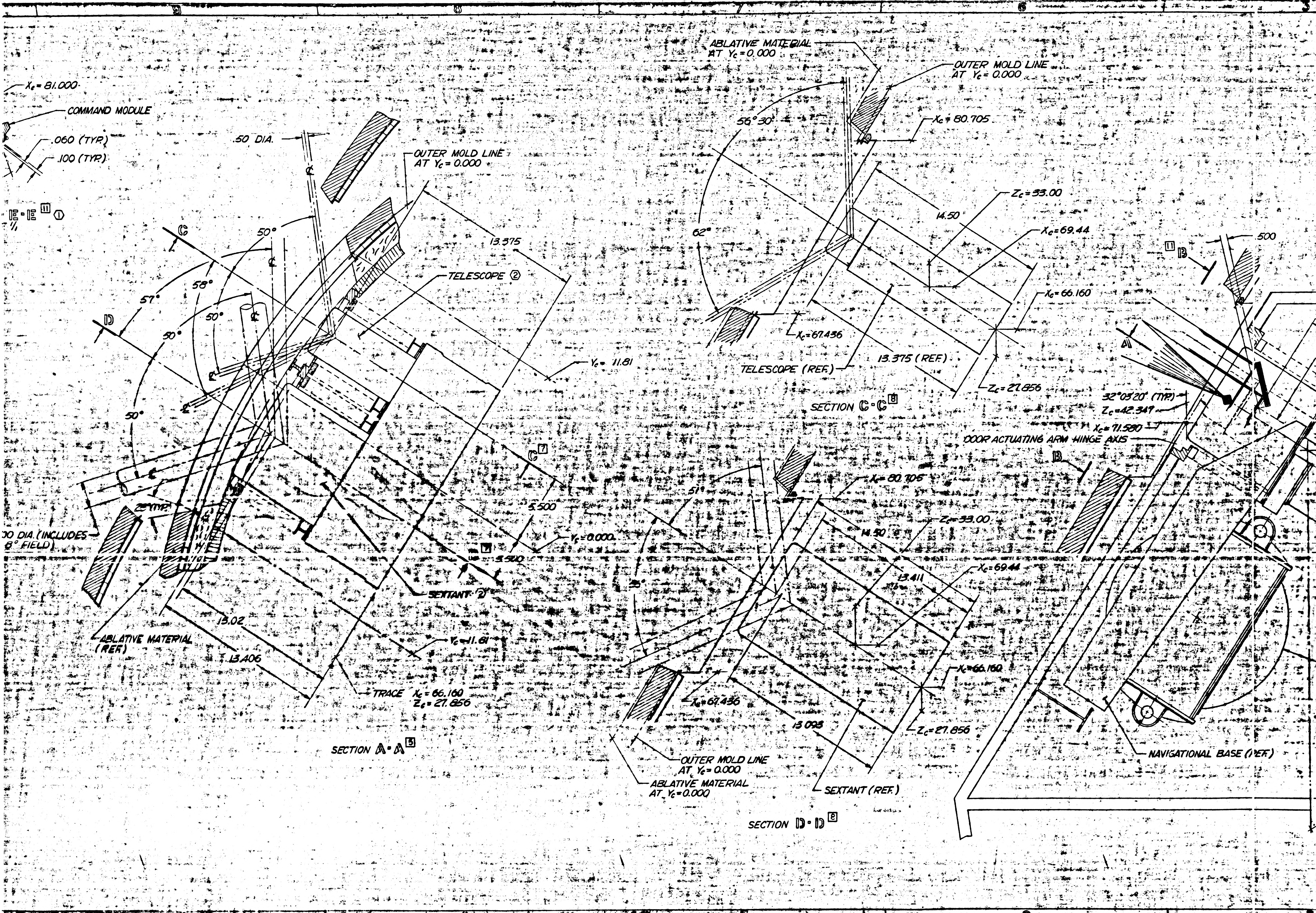
MH01-01215-116

MH01 0125116

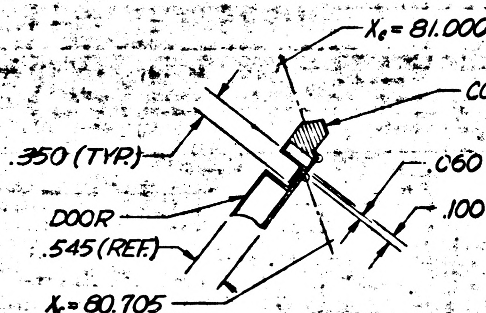

ABLATIVE MATERIAL AT $Y_c = 0.000$
OUTER MOLD LINE AT $Y_c = 0.000$
56° 30'
$X_c = 80.705$
$Z_c = 33.00$
14.50
62°
$X_c = 69.44$
$X_c = 66.160$
$X_c = 67.436$
$Y_c = 11.81$
TELESCOPE (REF.)
13.375 (REF.)
$Z_c = 27.856$
SECTION C-C [8]
.500
[11] B
$X_c = 80.750$
A
.750 RADIUS OF GYRATION
FOR MOUNTING OF SEXTANT, TELESCOPE & NAVIGATIONAL BASE SEE MH01-01201-116
11.00
32°03'20" (TYP.)
$Z_c = 42.347$
$X_c = 71.580$
DOOR ACTUATING ARM HINGE AXIS
B
$X_c = 69.440$
$X_c = 66.160$
℄ OPTICS
A [8]
51°
$X_c = 80.705$
0.000
14.50
$Z_c = 33.00$
13.411
$X_c = 69.44$
$X_c = 66.160$
$X_c = 67.436$
13.093
$Z_c = 27.856$
IMU (REF.)
NAVIGATIONAL BASE (REF.)
$X_c = 42.665$
$Z_c = 33.000$
OUTER MOLD LINE AT $Y_c = 0.000$
ABLATIVE MATERIAL AT $Y_c = 0.000$
SEXTANT (REF.)
SECTION D-D [8]
7
6
5
4
3

5. SPACECRAFTS
4. ALL REFERE
FOR PURPO
② 3. MASSACHUSE
① 2. NORTH AMER
DIVISION, D
1. THIS DOCUM
ALL PARTI
NOTES: UNLESS OTHER

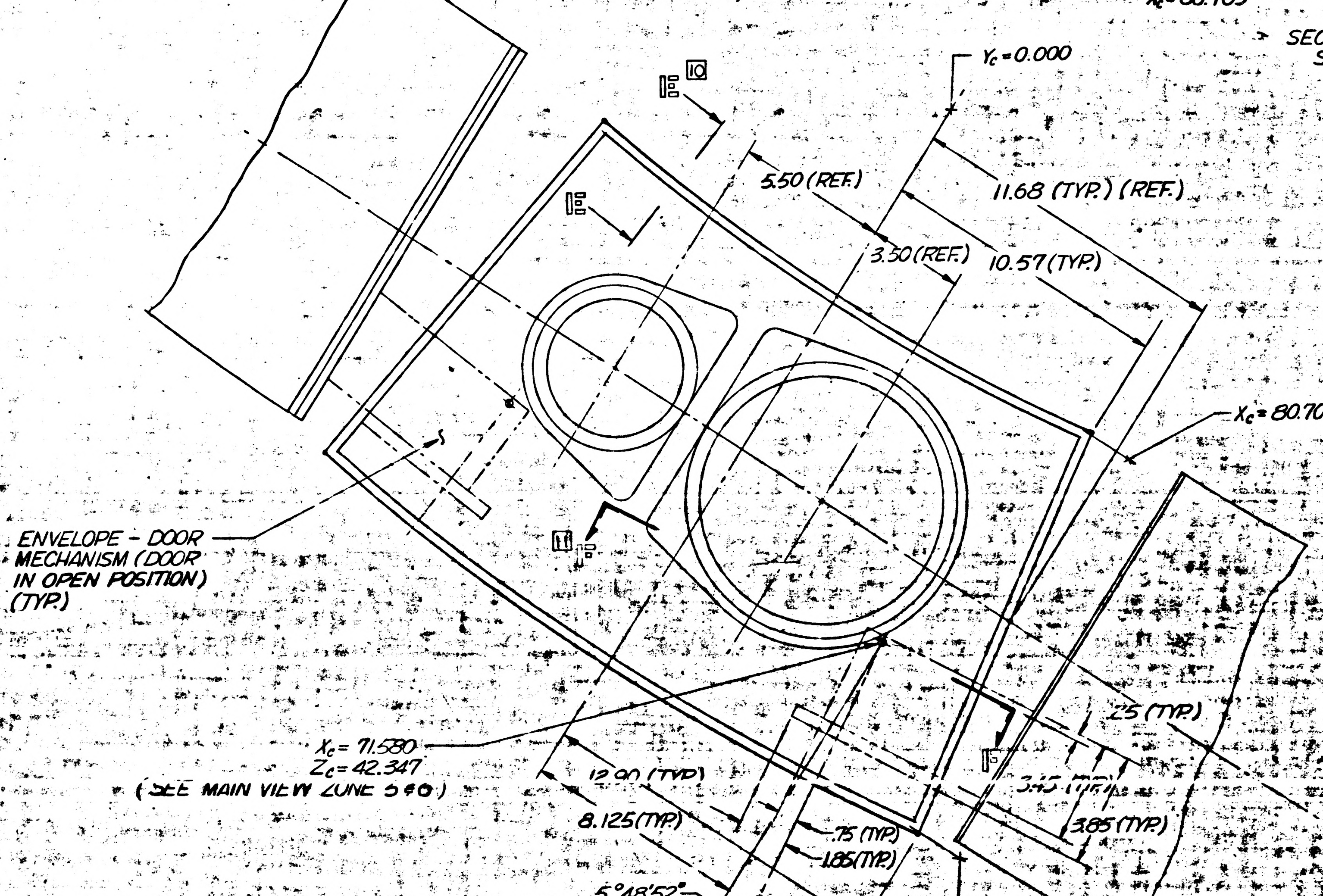
MH01 0125116


ABLATIVE MATERIAL AT $Y_c = 0.000$
OUTER MOLD LINE AT $Y_c = 0.000$
$X_c = 81.000$
COMMAND MODULE
.060 (TYP.)
.100 (TYP.)
.50 DIA.
OUTER MOLD LINE AT $Y_c = 0.000$
E-E ⑪ ①
1/1
C
50°
58°
57°
50°
50°
50°
D
13.375
TELESCOPE ②
$Y_c = 11.81$
C ⑦
5.500
$Y_c = 0.000$
5.500
25° (TYP.)
.00 DIA. (INCLUDES 8° FIELD)
SEXTANT ②
13.02
13.406
ABLATIVE MATERIAL (REF.)
$Y_c = 11.81$
TRACE $X_c = 66.160$ $Z_c = 27.856$
SECTION A-A ⑤
56° 30'
62°
$X_c = 80.705$
$Z_c = 33.00$
14.50
$X_c = 69.44$
$X_c = 66.160$
$X_c = 67.436$
13.375 (REF.)
TELESCOPE (REF.)
$Z_c = 27.856$
SECTION C-C ⑧
.500
⑪ B
A
32°03'20" (TYP.)
$Z_c = 42.347$
$X_c = 71.580$
DOOR ACTUATING ARM HINGE AXIS
B
51°
$X_c = 80.705$
$Z_c = 33.00$
14.50
13.411
$X_c = 69.44$
$X_c = 66.160$
$X_c = 67.436$
13.093
$Z_c = 27.856$
OUTER MOLD LINE AT $Y_c = 0.000$
ABLATIVE MATERIAL AT $Y_c = 0.000$
SEXTANT (REF.)
SECTION D-D ⑧
NAVIGATIONAL BASE (REF.)
9
8
7
6
5

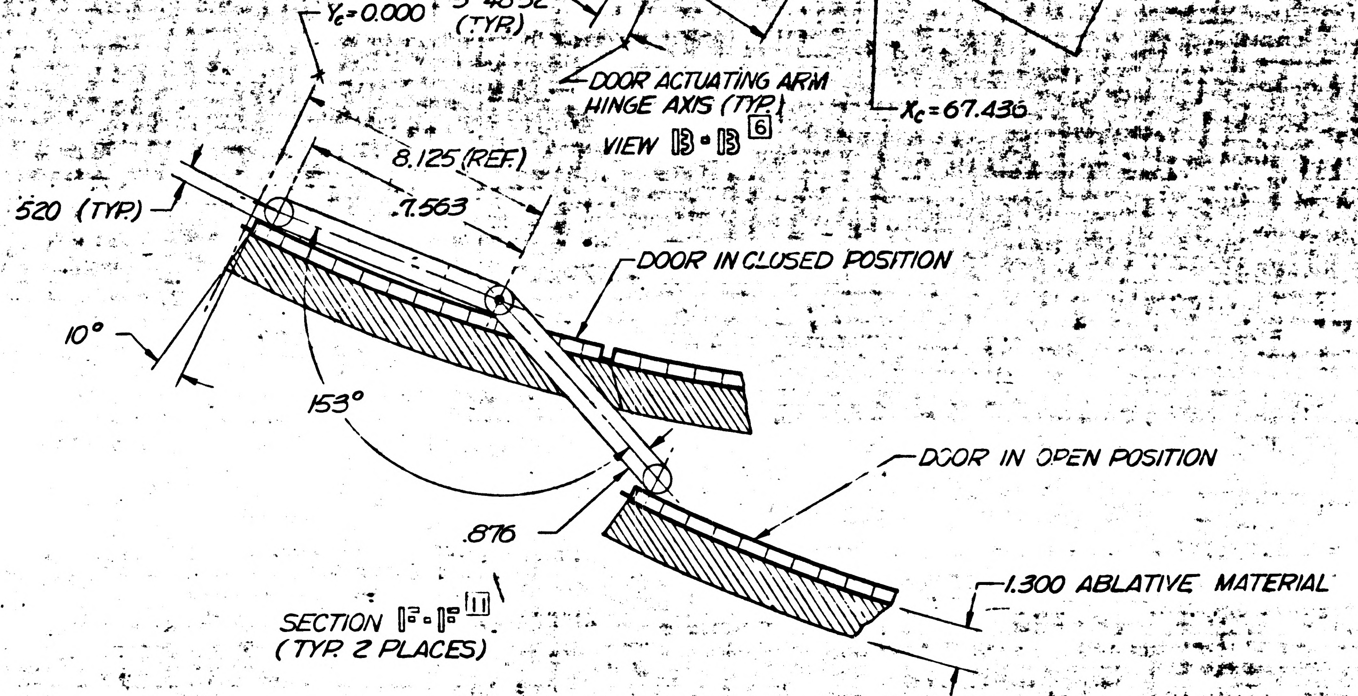
MH01 0125116


X_c = 81.000
COMMAND MODULE
.350 (TYP.)
.060 (TYP.)
DOOR
.100 (TYP.)
.545 (REF.)
X_c = 80.705

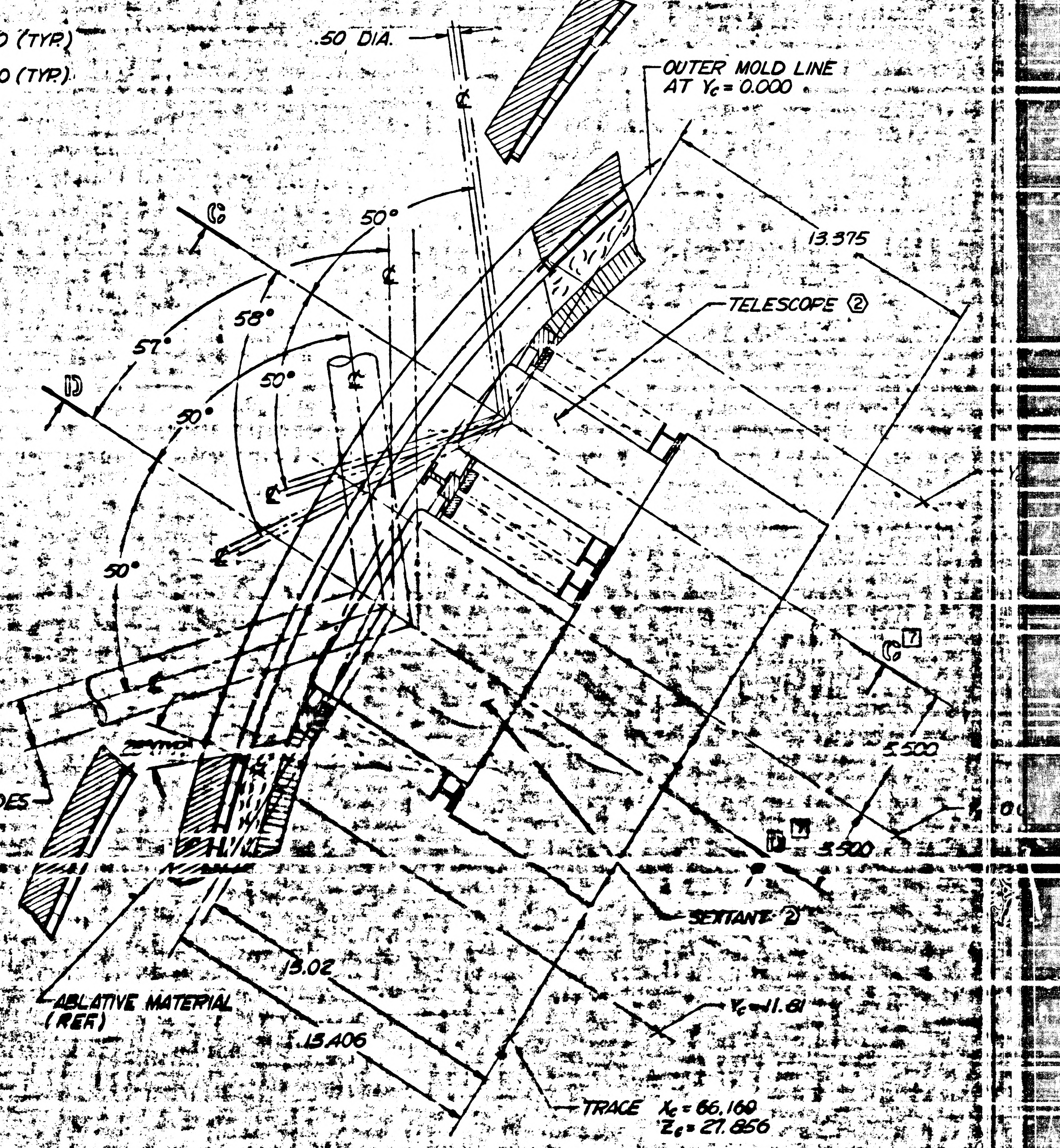
SECTION E-E [11] ①
SCALE 1/1


E [10]
Y_c = 0.000
E
5.50 (REF.)
11.68 (TYP.) (REF.)
3.50 (REF.)
10.57 (TYP.)
X_c = 80.705
ENVELOPE - DOOR MECHANISM (DOOR IN OPEN POSITION) (TYP.)
F [11]
F
.25 (TYP.)
X_c = 71.580
Z_c = 42.347
(SEE MAIN VIEW ZONE 5&6)
12.90 (TYP.)
3.45 (TYP.)
8.125 (TYP.)
3.65 (TYP.)
.75 (TYP.)
1.85 (TYP.)
Y_c = 0.000
5°48'52" (TYP.)
DOOR ACTUATING ARM HINGE AXIS (TYP.)
X_c = 67.436

VIEW B-B [6]


8.125 (REF.)
7.563
.520 (TYP.)
DOOR IN CLOSED POSITION
10°
153°
DOOR IN OPEN POSITION
.876
1.300 ABLATIVE MATERIAL

SECTION F-F [11]
(TYP. 2 PLACES)


.50 DIA.
℄
OUTER MOLD LINE AT Y_c = 0.000
C
50°
13.375
℄
TELESCOPE ②
58°
57°
D
50°
50°
℄
50°
50°
C [7]
.500
2.00 DIA. (INCLUDES 01.8° FIELD)
D [7]
3.500
SEXTANT ②
13.02
ABLATIVE MATERIAL (REF.)
Y_c = -1.61
13.406
TRACE X_c = 66.169
Z_c = 27.856

SECTION A-A [5]

MH01-01327-216

REVISIONS

TDRR 21387 AUG 6 1965

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NAA/S&ID	7/15/65
D. G. Hoag by A. Stamm	MIT	[illegible]

INTERFACE CONTROL DOCUMENT

DR BY
CHK BY

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

Guidance & Navigation Electrical Input Power
Block II - MIT_NAA

CODE IDENT NO. 03953
SIZE A
MH01-01327-216
SHEET 1 OF 11

Form M 110-M-57 Rev 4-63

REVISIONS

MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC

EFFECTIVITY AND SPECIFICATIONS

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
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CODE IDENT NO. 03953
SIZE A
MH01-01327-216
SHEET 2

REVISIONS

SYM	DESCRIPTION	REQD	REP	DATE	APPROVED

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO. 03953
SIZE A
MH01-01327-216
SHEET 3

REVISIONS

NOTES: Unless Otherwise Specified

(1) 1. North American Aviation, Inc.
Space and Information Systems Division
Downey, California

(2) 2. Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts

(3) 3. Refer to ICD MH01-01306-116 for additional connector details and location.

4. All reference documents shall be of latest issue.

(4) 5. The present MIT design provides a power ground which is in conflict with the CSM single point ground philosophy. NASA will provide NAA a waiver permitting this deviation to the standard CSM practice.

INTERFACE CONTROL DOCUMENT

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CODE IDENT NO. 03953
SIZE A
MH01-01327-216
SHEET

AUTHORIZED SIGNATURES	REPRESENTING	DATE
J. Lucas	NAA-S&ID	11/5/65
D.G. Hoag by W. Stameris	MIT	5 Nov 65

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT. NO. 03953

IRN NO. 10055

ICD NO.: MH01-01327-216

TITLE: Guidance and Navigation
Electrical Input Power
Block II - MIT/NAA

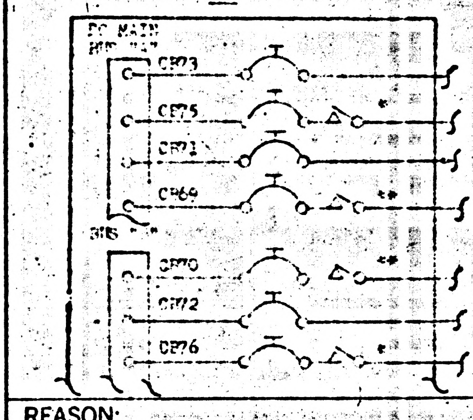
THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ASSOCIATE CONTRACTOR

ILLEGIBLE SEPIA

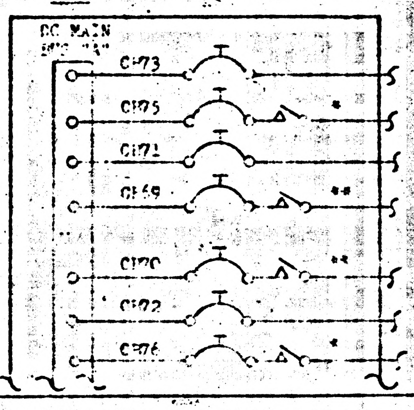
THIS IS BEST POSSIBLE MICROFILM
OBTAINABLE WITH SEPIA NOW ON HAND

DESCRIPTION Make the Following Change to Sheet 9:

NOW


DC MAIN
BUS "A"
CB73
CB75
CB71
CB69
BUS "B"
CB70
CB72
CB76
*
**
**
*

WAS


DC MAIN
BUS "A"
CB73
CB75
CB71
CB69
CB70
CB72
CB76
*
**
**
*

REASON:

Correct Schematic

TDRR 24052 NOV 16 1965

DR. BY A. F. Silagyi

FORM M 110-N-35 REV 7-65

REVISIONS

DC Power Characteristics:

Basic DC Steady State Voltage limits shall be 25.8 and 30.8 volts from input to negative return at G&N/S&ID electrical power interface.

Variations to Basic-DC Steady State Voltage:

	Max. Instantaneous Values	Min. Instantaneous Values	Utilization
a.	31.8 VDC	25.8	At all times (due to bus ripple) with the exception of those listed in b, c, and d.
b.	31.8 VDC	24.0	Starting gimbal motors (approximately five minutes prior to Delta V's) shall return to normal limits in less than one second for each motor "start" pulse.
c.	32.8 VDC	25.8 VDC	Switching on of S/C battery prior to Delta V's or entry.
d.	+80 VDC	-24 VDC	Values are open circuit voltages. These are random voltage pulses of 10 microseconds maximum duration. Equipment shall be tested for compatibility as specified in Figure #1. Source impedance of the pulses shall not be less than that of the test circuit specified in Figure 1.

REVISIONS

Power Interruption: There shall be no interruption of DC power to loads, from prelaunch through earth landing flight phases for normal or emergency operations modes.

Power Loads:

	Maximum	Nominal	Minimum
AGC Operate	130	110	90
Standby	12	10	8
Optics	150	130	90
IMU Operate	380	300	220
Standby	80	60	40
Displays and Controls	70	40	20
TOTAL	730	580	420

Power Source: The Guidance and Navigation System shall operate from the spacecraft DC and AC supply or its simulated equivalent.

④ **Negative Connection:** Negative bus power return for the AGC will be connected to the AGC chassis through a choke. Negative bus power returns for other G&N subsystems shall be DC isolated from MIT chassis and shall be grounded, by NAA, at the negative bus only.

Neutral Connection: Neutral bus power return terminals shall be isolated from MIT chassis and from negative DC terminals and shall be grounded, by NAA, at the neutral bus only.

Circuit Breaker Ratings:

CB #73, 10 Amp CB #74, 10 Amp	COMPUTER (Operate and Standby)
CB #75, 10 Amp CB #76, 10 Amp	Optics
CB #69, 25 Amp CB #70, 25 Amp	IMU (Operate)
CB #71, 7.5 Amp CB #72, 7.5 Amp	IMU HTR
CB #67, 2.0 Amp CB #68, 2.0 Amp	AC POWER

Isolation: Isolation between the spacecraft 28 VDC bus "A" and 28 VDC bus "B" shall be provided by diodes within the G&N System. These diodes shall have a "peak" inverse voltage capability of greater than 60 volts.

REVISIONS

Peak Power: The peak power drawn by the G&N System shall not exceed 700 watts DC and 57 watts AC (exclusive of short durations transients of 5 sec. maximum).

AC Power Characteristics:

Power Phases: Single phase

Power Frequency: 400 cps

Tolerance:

Normal operating tolerance is negligible (sychronized to master timing system).

Emergency: 400 ± 7 cps (loss of master timing signal)

Basic AC Steady State Voltage limits shall be 111.0 and 119.0 volts rms.

Variations to Basic AC Steady State Voltage:

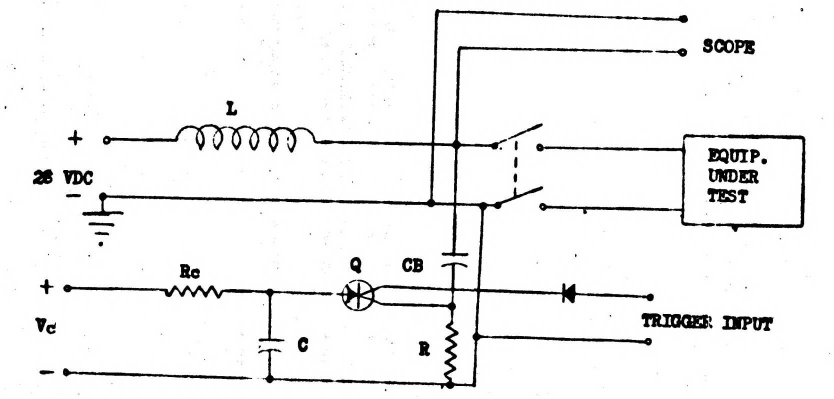
1. Normal operational instantaneous voltage limits greater than basic steady state voltage, may be 50 and 150 volts rms returing to 105 - 125 volts rms within 15 ms and to basic steady state limits within 50 ms.
2. Abnormal instantaneous high limit voltage for greater duration than normal operational high limit voltage, may be 150 volts rms for 100 ms.
3. Modulation: 0.5 percent
4. Inverter Failure: There is a maximum of 1 minute switchover time for AC power in the event the primary inverter fails and switchover to secondary inverter is required.

Wave Shape:

Sinusoidal	
Total Distortion:	5% Maximum of Fundamental
Highest Harmonic:	4% Maximum of Fundamental
Crest Factors:	1.414 ± 10%

REVISIONS

TRANSIENT SUSCEPTIBILITY TEST



Trigger Specifications:

Duration:	less than 20 usec.
Rate:	10 pps
Ampl.:	50 to 85 milliamps into zero resistance load
Rise Time:	0.5 usec. or less

R = 5 ohms nominal, carbon, 1/2 watt
C = Nominal 1 ufd, paper, 600 wvdc
Rc = Nominal 10K, carbon, 1 watt
CB = 10 ufd, paper, 200 wvdc

Q = SCR min rating 10 a, 200 v
L = 250 μh
Vc = DC Source 100 to 150 V

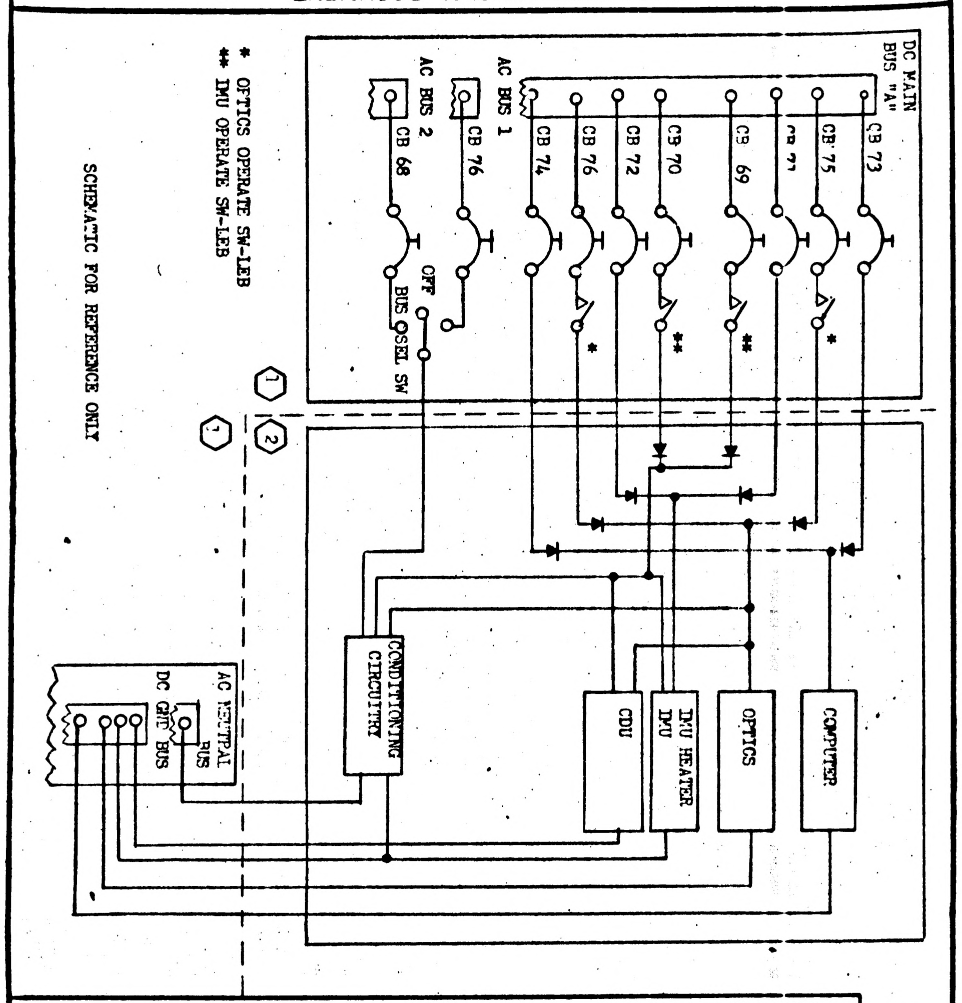
No change in indication beyond system tolerance, or temporary or permanent damage shall result in any equipment when a 50 volt pulse of 10 microsecond duration and a 10 pps repetition is induced above and below the 28 volt (nominal) DC supply voltage level for a period of 5 minutes minimum on either Bus A or Bus B lines.

The test circuit, as shown in the accompanying figure, shall be used. The existence of the 50 volt spike shall be measured with the test circuit in an open circuited configuration. The equipment to be tested is then connected to the test set-up, the repetitive pulses applied to the equipment input, and resultant effect on equipment measured.

"Equipment Under Test" shall be interpreted to mean the subsystem or subsystems which make up the equipment of one circuit breaker as shown on sheet 9. This test shall not be performed at any lower equipment level.

FIGURE 1

REVISIONS


DC MAIN BUS "A"
CB 73
CB 75
CB 71
CB 69
CB 70
CB 72
CB 76
CB 74
AC BUS 1
CB 76
AC BUS 2
CB 68
OFF
BUS SEL SW
COMPUTER
OPTICS
IMU HEATER
IMU
CDU
CONDITIONING CIRCUITRY
AC NEUTRAL BUS
DC GND BUS
*
**
1
2
3

* OPTICS OPERATE SW-LEB

** IMU OPERATE SW-LEB

SCHEMATIC FOR REFERENCE ONLY

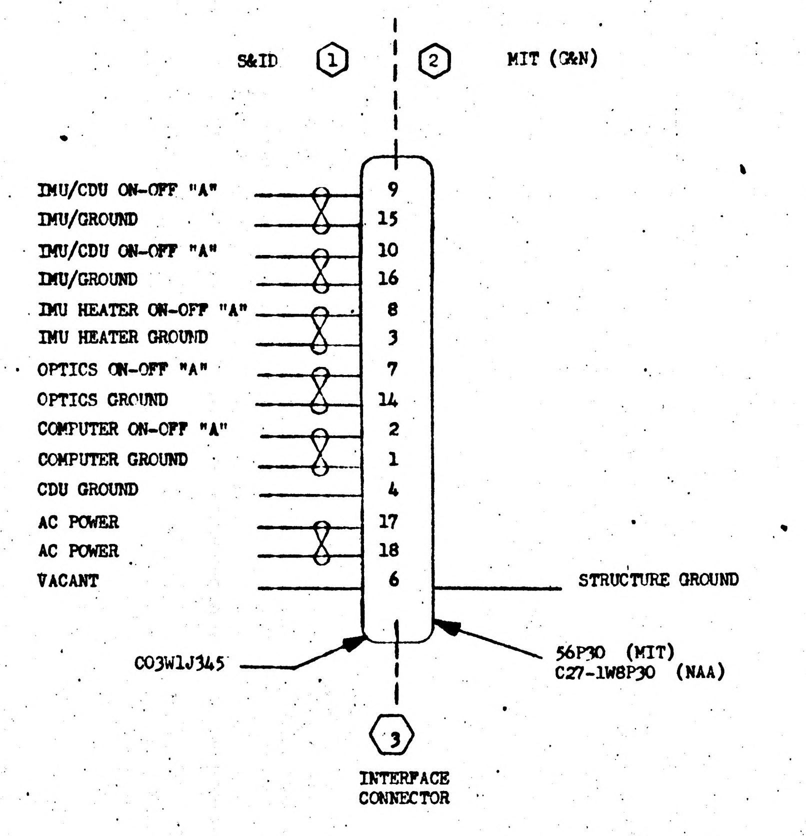
INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-01327-216
		SHEET 9

REVISIONS


S&ID
1
2
MIT (G&N)
IMU/CDU ON-OFF "A"
IMU/GROUND
IMU/CDU ON-OFF "A"
IMU/GROUND
IMU HEATER ON-OFF "A"
IMU HEATER GROUND
OPTICS ON-OFF "A"
OPTICS GROUND
COMPUTER ON-OFF "A"
COMPUTER GROUND
CDU GROUND
AC POWER
AC POWER
VACANT
9
15
10
16
8
3
7
14
2
1
4
17
18
6
STRUCTURE GROUND
C03W1J345
56P30 (MIT)
C27-1W8P30 (NAA)
3
INTERFACE CONNECTOR

INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

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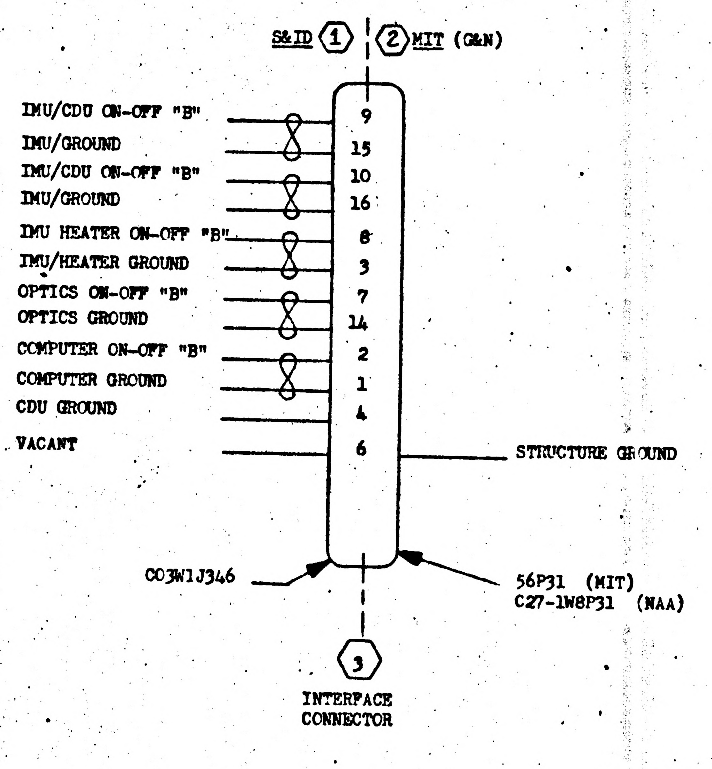
CODE IDENT NO.	SIZE	
03953	A	MH01-01327-216
		SHEET 10

REVISIONS


S&ID
1
2
MIT (G&N)
IMU/CDU ON-OFF "B"
IMU/GROUND
IMU/CDU ON-OFF "B"
IMU/GROUND
IMU HEATER ON-OFF "B"
IMU/HEATER GROUND
OPTICS ON-OFF "B"
OPTICS GROUND
COMPUTER ON-OFF "B"
COMPUTER GROUND
CDU GROUND
VACANT
9
15
10
16
8
3
7
14
2
1
4
6
STRUCTURE GROUND
C03W1J346
56P31 (MIT)
C27-1W8P31 (NAA)
3
INTERFACE CONNECTOR

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-01327-216
		SHEET 11

REVISIONS 4-8-66

TDRR 28861 MAY 17 1966

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
Ralph A. Kennedy	NAA/S&ID	4/12/66
W. A. Stameris	MIT/IL	4 May 66

INTERFACE CONTROL DOCUMENT

DR BY	E. BEATTIE	1-31-66
CHK BY		

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

COMPONENT INSTALLATION PROCEDURES
BLOCK II GUIDANCE & NAVIGATION SYS
TO COMMAND MODULE NAA-MIT

CODE IDENT NO.	SIZE	
03953	A	MH01-01350-416

1 of 29

REVISIONS

TDRR 28861 MAY 17 1966

MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC

EFFECTIVITY AND SPECIFICATIONS

INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-01350-416

SHEET 2

REVISIONS

SYM	DESCRIPTION	REQD	REP	DATE	APPROVED

TDRR 28861 MAY 17 1966

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-01350-416

SHEET 3

REVISIONS

NOTE: UNLESS OTHERWISE SPECIFIED

1. This document, with authorized signatures and supplemented by any and all valid Interface Revision Notices, reflects mutual agreement among those parties listed:

   ⟨1⟩ North American Aviation, Inc.
   Space and Information Systems Division
   Downey, California (NAA/S&ID)

   ⟨2⟩ Massachusetts Institute of Technology
   Instrumentation Laboratory
   Cambridge, Massachusetts (MIT/IL)

   ⟨3⟩ Design Data Required

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-01350-416

SHEET 4

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1.0 GENERAL

1.1 Introduction

This ICD outlines the steps required for initial installation of the Block II G&N System into the Block II Apollo Command Module and removal of individual components of G&N.

1.2 Conditions

1.2.1 All NAA-G&N interface electrical harnesses shall have been installed and tested for continuity and insulation resistance in accordance with applicable NAA drawings and process specifications.

1.2.2 The interior command module atmosphere will not exceed 125°F during or after system installation.

1.2.3 A water glycol coolant solution shall be provided to the G&N with flow rates and inlet temperatures as specified in ICD MH01-01349-416.

1.2.4 The installation or removal of the G&N equipment will be accomplished in an environment equal to Class 100,000 or better per Federal Specification No. 209.

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1.3 Safety Requirements

1.3.1 All circuit breakers supplying power to the G&N System shall be in the "OFF" position.

1.3.2 All signal carrying circuits going to the G&N System shall be de-energized.

1.3.3 Personnel safety is the direct responsibility of NAA and NASA supervision. Supervision is responsible for providing safe working conditions and obtaining personnel compliance with all NAA special working rules and regulations.

1.3.4 Perform a thorough visual examination of all equipment to detect possible physical damage and check for sharp edges and abrasion points which could be hazardous to personnel installating G&N equipment as well as to cables and harnesses.

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1.4 Abbreviations

ACED	AC Electronics Division
ACR	Associate Contractor
AMPL	Amplifier
ASSY	Assembly
CAL	Calibrate
CDU	Coupling Data Unit
CMC	Command Module Computer
C/M	Command Module
CONN	Connector
CW	Clockwise
CCW	Counterclockwise
D&C	Display and Control
DSKY	Display and Keyboard
ECS	Environmental Control System
EQUIP	Equipment
ELEC	Electrical
ESU	Eyepiece Stowage Unit
FT-LB	Foot/Pound
FLEX	Flexible
FWD	Forward
G&N	Guidance and Navigation
GFE	Government Furnished Equipment
GFP	Government Furnished Property
GSE	Ground Support Equipment
HTR	Heater
HD	Head
HEX	Hexagon
ICTC	Inertial Components Temperature Controller
ICD	Interface Control Document
IN-LB	Inch/Pound
IN-OZ	Inch/Ounce
IMU	Inertial Measurement Unit
LH	Left Hand
MIT/IL	Massachusetts Institute of Technology, Instrumentation Laboratory
NAA/S&ID	North American Aviation, Inc., Space and Information Systems Division
NAV	Navigation
NO.	Number
OPT	Optics
OUA	Optics Unit Assembly
PIPA	Pulse-Integrating Pendulum Accelerometer
PWR	Power

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2.0 Applicable Documents

2.1 Interface Control Documents

2.1.1 MH01-01301-116, Block II G&N Nav Base/Optics to C/M Structure

2.1.2 MH01-01302-116, Block II CMC-CDU to C/M Structure

2.1.3 MH01-01303-116, Block II PSA to C/M Structure

2.1.4 MH01-01304-116, Block II G&N Controls & Displays to C/M Structure

2.1.5 MH01-01305-116, Block II CMC DSKY to C/M Structure

2.1.6 MH01-01306-116, Block II G&N Wire Routings to C/M Structure

2.1.7 MH01-01308-116, Block II Coolant Lines and Connections to C/M Structure

2.1.8 MH01-01349-416, Block II G&N Thermal Requirements

2.1.9 MH01-01316-116, Block II G&N Eyepiece Stowage Unit

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3.0 Material and Equipment

3.1 Material

3.1.1 DC 340 Heat Transfer Compound ①

3.2 Equipment

3.2.1 GFE/GSE

3.2.1.1 G&N Transportation Cart Model No. H23-122.

3.2.1.2 IMU Installation Cable Model No. A23-114 (C14-462 to IMU).

3.2.1.3 Optics Handling Fixture Model No. ③②

3.2.1.4 Optics Eyepiece Hole Covers Part No. ③②

3.2.1.5 Optics Covers Model No. A23-166

3.2.1.6 Inertial Components Temperature Controller Model No. S23-100

3.2.1.7 Cover Kits, Electrical Connection

H23-194 (Optics)
H23-208 (CMC Group)
H23-209 (Guid Equip)

3.2.1.8 IMU Mounting Pad Covers, Part No. 2018816

3.2.2 NAA/GSE

3.2.2.1 G&N C/M Equipment Handling Set, Model No. ③①

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4.0 INSTALLATION REQUIREMENTS

When the requirements of this ICD conflict with other NAA/MIT requirements, the other ICD requirements shall have precedence.

4.1 IMU Coolant Flex Lines

4.1.1 Install flexible coolant lines per ICD MH01-01308-116.

4.1.2 Torque mechanical connections to 175-200 in-lbs torque.

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4.2 Nav Base Forward Mounts

4.2.1 Install the LH and RH Forward Mounts per ICD MH01-01301-116 using shims if required to obtain dimensions shown.

4.2.2 Tighten fasteners to 140 ± 15 in-lbs torque.

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4.3 PIPA Calibration Assembly

4.3.1 Apply Heat Transfer Compound to interface surfaces being careful not to allow any compound to enter screw threads or mounting holes.

4.3.2 Install PIPA Cal. Assy per ICD MH01-01304-116, except do not install fastener used to secure cable clamp as specified on ICD MH01-01306-116. Tighten fasteners to 25 ± 2 in-lbs torque.

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4.4 Signal Conditioner Assembly

4.4.1 When installing the Signal Conditioner Assy, feed connector branch consisting of connectors 30J1, 30J2, and 30J3 through access hole in upper portion of the right hand vertical panel.

4.4.2 Install Signal Conditioner Assemply per ICD MH01-01304-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.4.3 Attach connectors 30J1, 30J2, and 30J3 to connector breacket per ICD MH01-01306-116. Tighten Jam nuts ⟨3⟩⟨1⟩ in-lbs torque and safety wire with .032 diameter lockwire.

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4.5 G&N Harness Group

NOTE: Locating bands determine position of harnesses in center of cable clamps.

4.5.1 Install hinged loop cable clamps per ICD MH01-01306-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.5.2 Install the "B" Harness Assy per ICD MH01-01306-116.

4.5.2.1 Secure harness with hinged loop Cable Clamps. Tighten Clamp Center screws to 30 ± 3 in-lbs torque.

4.5.3 Obtain the "C" Harness Assy and remove protective cover from connector 56P12. Remove protective cover from connector 35A2J14 on PIPA Cal Assy and mate 56P12 to 35A2J14.

4.5.3.1 Secure harness with cable clamps and spacers per ICD MH01-01306-116. Tighten loop clamp center screws to 25 ± 2 in-lbs torque.

4.5.4 Remove LH interface connector bracket from structure and attach connector 56J1, 56J2, 56J3, and 56J4 on the "D" Harness Assy to connector bracket per ICD MH01-01306-116. Tighten fasteners to 50 ± 5 in-oz torque.

4.5.4.1 Feed connector 56P17 through access hole in LH panel and attach interface connector bracket to LH panel per ICD MH01-01306-116.

4.5.4.2 Secure harness with hinged loop Cable Clamp per ICD MH01-01306-116. Tighten Clamp Center screw to 30 ± 3 in-lb torque.

4.5.5 Obtain the "G" Harness Assy and attach loop type clamps per ICD MH01-01306-116.

4.5.5.1 Install harness and secure in place with loop clamps and hinged loop clamps per ICD MH01-01306-116, except do not secure clamp nearest connector 56P29 at this time. Tighten clamp center screws to 30 ± 3 in-lbs torque. Tighten fasteners to 25 ± 2 in-lbs torque.

4.5.5.2 Coil neatly the harness branch consisting of connectors 56J6, 56J7 and 56J8 and temporarily secure to connector bracket. To be connected to ESU on its installation.

4.5.5.3 Remove protective covers from 56P20, 56P21, and 56P22, and mate 56P20 to 30J1, 56P21 to 30J2, and 56P22 to 30J3 on the Signal Conditioner Assy interface connector bracket per ICD MH01-01306-116.

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4.5.5.4 Feed connector 56P32 through the lower access hole of panel.
NOTE: Do not mate with connector C03W1J347 at this time.

4.5.6 Obtain the "H" Harness Assy and attach loop clamps per ICD MH01-01306-116.

4.5.6.1 Install the "H" Harness Assy and feed connectors 56P30 and 56P31 through the lower access hole in the RH panel. Do not mate connectors 56P30 to C03W1J345 (A Bus Power) and 56P31 to C03W1J346 (B Bus Power) at this time.

4.5.6.2 Attach "H" Harness to RH panel with hinged loop clamps per ICD MH01-01306-116. Tighten Clamp Center screws to 30 ± 3 in-lbs torque.

4.5.6.3 Remove protective cover from 56J5 and attach to CMC/CDU-PSA LH interface connector bracket per ICD MH01-01306-116. Tighten fasteners to 50 ± 5 in-oz torque.

4.5.6.4 Attach harness to Nav Base Lower Support Beam per ICD MH01-01306-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.5.7 Install the "F" Harness Assy per ICD MH01-01306-116.

4.5.7.1 Secure harness with hinged loop cable clamps. Tighten Clamp Center screws to 30 ± 3 in-lbs torque.

4.5.8 Install the "E" Harness Assy per ICD MH01-01306-116.

4.5.8.1 Secure harness with hinged loop cable clamps. Tighten Clamp Center screws to 30 ± 3 in-lbs torque.

4.5.9 Secure "G" Harness hinged loop clamp rear 56P29 (REF Para 4.5.5.1). Tighten clamp center screw to 30 ± in-lbs torque.

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4.6 Nav DSKY

4.6.1 Remove the vertical panel on the RH side of DSKY area.

4.6.2 Install DSKY and attach to LH flange per ICD MH01-01304-116. Leave fasteners loose.

4.6.3 Replace RH panel.

4.6.4 Raise DSKY sufficiently to allow fasteners to be installed in RH panel per ICD MH01-01304-116. Tighten all fasteners to 25 ± 2 in-lbs torque.

4.6.5 Remove protective cover from 56P25 of the "H" Harness Assy and 05A2-J1 on rear of DSKY.

4.6.6 Mate 56P25 to 05A2-J1.

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4.7 Navigation Base Assembly

4.7.1 Verify there are protective covers on mounting pads for IMU and OUA.

4.7.2 Install Nav Base Assy per ICD MH01-01301-116. Tighten FWD mount fasteners to 260 ± 10 in-lbs torque. Tighten AFT mount fasteners to 70 ± 5 in-lbs torque.

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4.8 Optics Unit Assembly

4.8.1 Attach OUA Handling Fixture to the OUA.

4.8.2 With OUA held in handling fixture, insert dowel pins in Optics Base mounting holes (three places).

4.8.3 Obtain three precision balls (3/4 diameter) and place one each onto dowel pins.

4.8.4 Obtain Optics Bellows Seals and install to Bellows Assy using six Seal Retaining Springs (three each seal).

4.8.5 Install four dowel pins in threaded holes of Bellows flange (two each bellows).

4.8.6 Remove protective covers from ball seats on Nav Base. Using handling fixture, bring OUA to mate with the Nav Base and C/M. As the bellows approach C/M, pilot dowel pins into flange holes. As the OUA approaches Nav Base, pilot dowel pins and precision balls into mating seats.

4.8.7 Maintain positive pressure on OUA to prevent ball movement, remove dowel pins and insert Bolt Assy (bolt, bellville washers, spacer, and centering collar) and torque bolts to ③ ② in-lbs, then back off 90° ± 10°.

4.8.8 Install bolts which secure bellows assembly to C/M (except holes with dowel pins) per ICD MH01-01301-116. Hand tighten only.

4.8.9 Remove dowel pins and complete bolting. Tighten bolts in 10 in-lbs increments in sequence shown on ICD MH01-01301-116 until all bolts are tightened to 27 ± 3 in-lbs torque. Safety wire in place.

4.8.10 Demate OUA Handling Fixture and return it to the G&N Transportation Cart.

4.8.11 Remove protective covers from Connector 56P13 and 56P14 of the "B" Harness Assy and 65A1J1 and 65A1J2 on the OUA. Mate 56P13 to 65A1J1 and 56P14 to 65A1J2.

4.8.12 Remove protective covers from connector 56P23 of the "F" Harness Assy and 65A2J1 on the OUA and mate.

4.8.13 If the IMU is not to be installed within twenty-four hours, complete paragraphs 4.13 and 4.14 at this time (Installation of Optics Shroud and Cover).

INTERFACE CONTROL DOCUMENT

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4.9 Eyepiece Stowage Unit

4.9.1 Attach mounting brackets to structure per ICD MH01-01316-116. Tighten fasteners to within two turns of full engagement.

4.9.2 Attach Connectors 56J6, [illegible] and 56J8 of Harness Branch [illegible] to mounting brackets per ICD MH01-01306-116.

4.9.3 Attach harness to bracket with loop clamps per ICD MH01-01306-116.

4.9.4 Remove the SXT Eyepiece Assy from the ESU and mate 56J6 to 65A1P3.

4.9.5 Support eyepiece to allow installation of ESU ③ ②, ① .

4.9.6 Remove the SCT Eyepiece Assys from the ESU and mate [illegible] 56J8 to 65[illegible]3.

4.9.7 Support eyepiece to allow installation of ESU ③ ② ① .

4.9.8 Attach ESU to mounting bracket per ICD MH01-01316-116.

4.9.9 Stow SXT and SCT eyepieces in ESU.

4.9.10 Tighten fasteners installed in paragraph 4.9.1 to 25 ± 2 in-lb torque.

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4.10 Power and Servo Assembly

4.10.1 Position the PSA Coldplate with attached flex coolant lines approximately 3 1/2 inches above the girth shelf (X_c 42.665) and withdrawn from its installed position approximately 16 inches.

4.10.2 Apply Heat Transfer Compound to the interface surface of the PSA or coldplate being careful not to allow any compound to enter screw threads or mounting holes.

4.10.3 While the PSA Coldplate is being supported, insert the PSA under the Coldplate until it is approximately in alignment with the coldplate.

4.10.4 Position the coldplate with respect to the PSA and secure the coldplate to the PSA per ICD MH01-01303-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.10.5 Carefully slide the PSA with coldplate attached back under Nav Base to installed position. Per ICD MH01-01303-116.

4.10.6 Secure the PSA to C/M per ICD MH01-01303-116. Tighten fasteners to 60 ± 5 in-lbs torque.

4.10.7 Remove protective covers from connector 56P17 ("D" Harness) and 45J4 (PSA).

4.10.7.1 Place the connector gasket ② over locating pins on the equip connector half over the equip half using locating pins on the equip connector. Tighten the four corner fasteners sequentially in two turn increments until a torque of 14 ± 1 in-lbs is attained on each fastener. Tighten the remaining two fasteners to a torque of 14 ± 1 in-lbs.

4.10.8 Remove protective covers from connector 56P19 ("C" Harness) and 45J6 (PSA). Mate connector 56P19 to 45J6 per paragraph 4.10.7.1.

4.10.9 Remove protective covers from connector 56P18 ("B" Harness) and 45J5 (PSA).

4.10.9.1 Place the connector gasket ② over locating pins on the equip connector half. Position the harness connector half over the equip half using the locating pins on the equip connector. Tighten the four corner fasteners sequentially in two turn increments until a torque of 14 ± 1 in-lbs is attained on each fastener.

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4.10.10 Remove protective covers from connector 56P29 ("G" Harness) and 45J11 (PSA). Mate connector 56P29 to 45J11 per paragraph 4.10.7.1.

4.10.11 Remove protective covers from connector 56P27 ("H" Harness) and 45J8 (PSA). Mate connector 56P27 to 45J8 per paragraph 4.10.9.1.

4.10.12 Remove protective covers from connector 56P28 ("F" Harness) and 45J10 (PSA). Mate connector 56P28 to 45J10 per paragraph 4.10.9.1.

4.10.13 Remove protective covers from connector 56P26 ("E" Harness) and 45J7 (PSA). Mate connector 56P26 to 45J7 per paragraph 4.10.9.1.

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4.11 CMC/CDU Assemblies

4.11.1 Position the CMC and CDU on the installation fixture per ICD MH01-01313-100 and attach hinged loop cable clamps to CMC & CDU per ICD MH01-01302-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.11.2 Remove protective covers from connector 40 ③ ⟨2⟩ on CDU and 05 ③ ⟨2⟩ on CMC.

4.11.3 Obtain the "A" Harness Assy and remove protective covers from 56P9 and 56P10. Mate 56P9 to 40J53 and 56P10 to 05A5J1 per paragraph 4.10.7.1.

4.11.4 Attach harness to the CMC and CDU with hinged loop cable clamps. Tighten clamp center screw to 30 ± 3 in-lbs torque.

4.11.5 Install CMC/CDU and attach to C/M structure per ICD MH01-01302-116.

NOTE: While installing the CMC/CDU, feed the eight loose connectors of the "A" Harness Assy up through the access hole in girth shelf.

Apply heat transfer compound to the interface surface of the CMC/CDU or coldplate being careful not to allow any compound to enter screw threads or mounting holes.

Tighten all fasteners to 65 ± 5 in-lbs torque.

4.11.6 Attach cable group of the "A" Harness Assy consisting of 56P6, 56P7, and 56P8 to the RH connector bracket with loop clamp per ICD MH01-01306-116. Tighten fastener to 25 ± 2 in-lbs torque.

4.11.7 Remove protective covers from connectors 56P6, 56P7, and 56P8 and on the LH connector brackets mate 56P6 to C03W2J337 and 56P8 to C03W2J335 per ICD MH01-01306-116.

4.11.8 Remove protective covers from connectors 56P1, 56P2, 56P3, 56P4, and 56P5 of the "A" Harness Assy and on the RH Connector Bracket mate 56P5 to 56J5, 56P4 to 56J4, 56P3 to 56J3, 56P2 to 56J2, and 56P1 to 56J1 per ICD MH01-01306-116.

4.11.9 Secure the "A" Harness Assy with Channel Clamp to C/M per ICD MH01-01306-116.

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4.12 Inertial Measurement Unit

NOTE: If Optics Shroud and Cover were installed per paragraph 4.7.13, both must be removed before proceeding with IMU installation.

4.12.1 At the time of installation the IMU shall not contain coolant.

4.12.2 Verify that the Portable Temperature Controller is connected to the IMU and is operating correctly. Verify that the extension cable is coiled neatly, with no tangles, so it can be played out smoothly.

4.12.3 Attach the IMU Installation Fixture to the IMU per ICD MH01-01313-100.

4.12.4 Raise the Assy up and away from the G&N Transportation Cart.

4.12.5 Remove the mounting pad covers from the IMU and verify the mounting surfaces are bright, clean, and free from scratches.

4.12.6 Remove the mounting pad covers from the Nav Base Assy and verify the mounting surfaces are bright, clean, and free from scratches.

4.12.7 Transfer the IMU into the C/M. Position the IMU so that the coolant connections are lowermost, holes in the IMU and Nav Base mounting pads are in alignment, and mounting surfaces of IMU and Nav Base are parallel using special alignment pins ⟨2⟩ installed in upper and lower holes in LH mounting pads on Nav Base.

4.12.8 Mate the IMU to Nav Base checking to make sure the separation distance between the four sets of mounting pads decrease by an equal amount.

4.12.9 Install one bolt each in the upper and lower RH corners of the IMU. Tighten to 25 ± 2 in-lbs torque.

4.12.10 Remove alignment pin in upper LH corner of the IMU and install precision bolt being careful the precision collar on bolt enters precision hole in IMU uncontrained. Tighten bolt to 25 ± 2 in-lbs torque.

4.12.11 Remove alignment pin in lower LH corner of the IMU and install precision bolt being careful the precision collar on bolt enters the precision slotted hole in Nav Base unconstrained. Tighten bolt to 25 ± 2 in-lbs torque.

4.12.12 Remove installation fixture.

4.12.13 Tighten the four bolts to 62 ± 2 in-lbs torque in 10 in-lbs increments in the following sequence: upper LH first, lower LH second, upper RH third, and lower RH fourth.

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4.12.14 NOTE: Connector 56P16 is not mated to 35A1J1 until heater power for the IMU can be supplied through the PSA connector 45J6.

Remove protective covers by cutting safety wire from connector 34A1J1 and 35A1J2 on the IMU. Remove protective covers from connector 56P16 on the "C" Harness Assy and mate to 35A1J2 on the IMU.

4.12.15 Remove dust covers from coolant fittings on the lower LH and RH corners of IMU by cutting safety wire.

4.12.16 Connect flexible lines to IMU per ICD MH01-01308-116.

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4.13 IMU Heater Power Through PSA

4.13.1 ③ ⟨2⟩

4.14 G&N Control Panel

4.14.1 Remove protective cover from connector 56P24 on the "E" Harness Assy and 50J1 on G&N Control Panel.

4.14.2 Install the G&N Control Panel per ICD MH01-01304-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.14.3 On the back side of the upper RH corner, mate connector 56P24 to 50J1.

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4.15 Optics Shroud Assy

4.15.1 Install Optics Shroud Assy per ICD MH01-01304-116. Tighten fasteners to 25 ± 2 in-lbs.torque.

4.16 Optics Cover Assy/Workshelf

NOTE: This assembly shall be installed as an optics cover, except when eyepieces are installed to OUA.

4.16.1 Obtain a NAA Workshelf Assy and install it on the front of the Optics Shroud per ICD MH01-01304-116.

4.17 [illegible]

4.17.1 Install Main DSKY per ICD MH01-01305-116. Tighten fasteners to 25 ± 2 in-lbs torque.

4.18 [illegible]

4.18.1 [illegible]

5.0 REMOVAL REQUIREMENTS

[illegible]

INTERFACE CONTROL DOCUMENT

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MH01 01350 416

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REVISIONS A, B

TDRK 28858 MAY 17 1966

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NAA	6-16-65
	GAEC	[illegible]
D. G. Hoag	MIT	16 Aug 65

INTERFACE CONTROL DOCUMENT

DR BY	G.A. Fatton	6-10-65
CHK BY		

NORTH AMERICAN AVIATION, INC.
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LEM/CSM Guidance and Navigation
(IMU Alignment)

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Form M 110-N-57 Rev 4-63

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TDRK 28858 MAY 17 1966

		LEM 1 & SUBS	
V 36-3	V36-000002	COMMAND MODULE 98, 101-112	SID 64-1345, 1347
MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC

EFFECTIVITY AND SPECIFICATIONS

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SYM	DESCRIPTION	REQD	REP	DATE	APPROVED
A	1. Effectivity Block added on page 2. 2. Para. 1.1 "SID" was changed to "NAA". 3. Para. 3.2.2 "will be" was changed to "are". 4. Para. 3.3.2.1.3 changed 7.2 to 11.2		GAEC NAA	1/21/65 1/6/65	E. Stern W. Mestheler
B	ADD GAEC LEM EFFECTIVITY		GAEC NAA MIT	2/2/66 2/2/66 7 Apr 66	R.D. Ramsey W. Stameris

INTERFACE CONTROL DOCUMENT

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-05076-414

SHEET 3 of 10

FORM M110-N-59 REV 4-63

M - 110 - N58

REVISIONS A, B

NOTES: (Unless Otherwise Specified)

This document represents agreement between the following organizations:

(a) North American Aviation, Inc.
Space and Information Systems Division
Downey, California

(b) Grumman Aircraft Engineering Corporation
Bethpage, Long Island
New York

(c) Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts

INTERFACE CONTROL DOCUMENT

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03953	A	MH01-05076-414

SHEET 4 of 10

1.0 SCOPE

1.1 This document represents NAA/GAEC/MIT agreements for performance, test, and qualification of the CSM/LEM interfaces pertaining to IMU alignment for Block II Apollo missions.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications and Documentation

2.1.1 Specifications

SID 62-1244, Apollo Lunar Excursion Module Performance and Interface Specification.

2.1.2 Documents

The following ICD's are either affected by the data in this ICD, or provide supporting data for this ICD.

MH01-05138-414 CSM/LEM Lunar Mission Definition

LID-340-10008 AOT Field of View

MH01-05053-416 CSM/LEM Docking Ground Rules

MH01-05128-116 CM-LEM Structural Interface

MH01-05057-416 CSM/LEM Docking Aids

2.2 Coordination Agreements and Correspondence

Minutes of NASA Coordination Meeting with Massachusetts Institute of Technology and Grumman Aircraft Engineering Corporation, Meeting Number L7A, dates 25, 26 June 1964.

2.2.2 Correspondence (For reference only)

NASA TWX No. PS5/T1688-64-1565, (NAA Log No. M12695MA), dated 1 December 1964. (Establishes CSM/LEM docking alignment.)

2.3 Applicable Dates

Unless specific revision dates are given, the latest document and/or revision date is applicable

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3.0 REQUIREMENTS

3.1 Purpose

The purpose of this document is to define the CSM/LEM interface characteristics required to assure proper LEM IMU alignment when the CSM and LEM are attached.

3.2 Mission Requirements

3.2.1 LEM IMU Coarse Alignment Prior to Separation

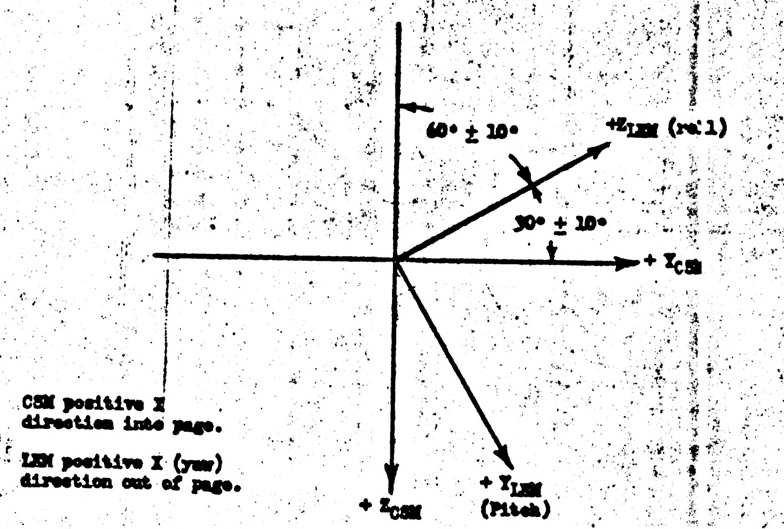
The initial coarse alignment of the LEM IMU in lunar orbit will be performed prior to LEM separation from the CSM. This alignment will be performed by orienting the LEM IMU gimbals with reference to the CSM IMU gimbals. Data on the orientation of the CSM IMU gimbals will be transferred to the LEM over the voice link.

3.2.2 LEM IMU Alignment Prior to Use of LEM Backup Propulsion

The LEM propulsion system will be capable of performing backup thrusting for earth/moon midcourse corrections and transearth injection within the constraints of fuel availability. Prior to such operations it will be necessary to both coarse and fine align the LEM IMU with the vehicles attached. Attitude constraints imposed upon the CSM during these functions will be controlled by ICD MH01-05138-414, CSM/LEM Lunar Design Mission.

3.3 Alignment Criteria

The LEM and CSM will be docked with their relative axis orientation as defined in ICD MH01-05057-416, Docking Aides paragraph number 3.1.2. This orientation results in the X (roll) axis of the CM being aligned with the X (yaw) axis of the LEM. The positive X axis of the CM will be in the direction of the negative X axis of the LEM. The LEM positive Z (roll) axis will align 60 degrees plus or minus 10 degrees from the CSM negative Z (yaw) axis and 30 degrees plus or minus 10 degrees from the CSM plus Y (pitch) axis. (See Figure 1). If any discrepancies exist between this paragraph and ICD MH01-05057-416 the referenced ICD [illegible] will be the governing document.


60° ± 10°
+Z LEM (roll)
30° ± 10°
+ Y CSM
+ Z CSM
+ Y LEM (Pitch)
CSM positive X direction into page.
LEM positive X (yaw) direction out of page.

NOTE: See Figures 1 and 2 of ICD MH01-05057-416, CSM/LEM Docking Aids, for relationships between vehicle axes and overall vehicle characteristics.

Vehicle and Navigation Base Axes
With LEM and CSM in Docked
Positions (Looking from CSM to LEM)

Figure 1

3.3.1 IMU Mounting Orientation

In both the CM and the LEM, the IMU's will be mounted such that the IMU reference axes are parallel to and have the same polarity as the vehicle axes. For zero gimbal angles, the gimbal axes will be aligned such that the outer gimbal axis shall have the same direction and polarity as the vehicle X axis, the middle gimbal axis shall have the same direction and polarity as the vehicle Z axis, and the inner gimbal axis shall have the same direction and polarity as the vehicle Y axis.

3.3.2 Total Coarse Alignment Uncertainty

The uncertainty in the LEM IMU alignment with respect to desired inertial coordinates at the completion of the coarse align function described in paragraph 3.2.1 above shall be less than 20 milliradians (rms) about the LEM Y (pitch) and Z (roll) axes and less than 40 milliradians (rms) about the LEM X (yaw) axis. The LEM X (yaw), Y (pitch), and Z (roll) axes shall be as shown in figure 1 of this ICD, and figures 1 and 2 of ICD MH01-05057-416, Docking Aides.

3.3.2.1 Coarse Alignment Uncertainty Components

The total coarse alignment uncertainty shall consist of the significant components identified in the following paragraphs.

3.3.2.1.1 CM Navigation Base Alignment

The CM navigation base alignment uncertainty shall include the CM stable member uncertainty within 60 minutes of the last fine alignment, CM stable member to navigation base uncertainty including CDC readout, and the CM navigation base to structural mounts uncertainty. This alignment uncertainty shall be less than 3 milliradians (rms) about each of the LEM orthogonal axes.

3.3.2.1.2 Manual Transfer of Alignment Angles

The manual transfer of alignment angle uncertainty shall include the resolution of the data transferred from the CM G&N to the LEM G&N and the uncertainty in the exact orientation of the vehicle at the time when the data are transferred. This alignment uncertainty shall be less than 0.58 milliradians (rms) about each of the LEM orthogonal axes.

3.3.2.1.3 CM Structural Alignment

The CM structural alignment uncertainty shall include the CM navigation base structural mounting surfaces manufacturing alignment uncertainty and the CM structural flexing uncertainty. For the Y (pitch) and Z (yaw) axes, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the docking interface. The docking surface alignment uncertainty shall include parallelism and non-uniformity of the CM docking interface. For the X (roll) axis, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the LET structural mounting surfaces. Also included for the X (roll) axis, is the structural flexing between the LET structural mounting surfaces and the docking interface. The alignment uncertainty shall have a randomly distributed component of less than 11.2 milliradians, rms about each of the LEM orthogonal axes. In addition, there shall be bias components of less than 4.1 milliradians about the LEM Y (pitch) axis, 4.4 milliradians about the LEM Z (roll) axis, and 0.9 milliradians about the LEM X (yaw) axis.

3.3.2.1.4 Docking Interface Roll Calibration Alignment

The docking interface alignment uncertainty shall include the hard docking interface alignment uncertainty in pitch and yaw. In roll, the relative orientation of the two vehicles shall be determined from calibrations on the LEM docking ring and a calibration marker on the CM docking ring, as shown in ICD MH01-05128-414, CM/LEM Structural Interface. The following two subsections define the CM and LEM components of the roll calibration alignment.

3.3.2.1.4.1 CM Roll Calibration Alignment

The alignment uncertainty of the calibration marker on the CM docking ring shall consist of the alignment of the marker with respect to the CM Y and Z axes.

This alignment uncertainty shall be less than 1.2 milliradians (rms) about the LEM X (yaw) axis.

3.3.2.1.4.2 LEM Roll Calibration Alignment

The LEM docking interface calibration alignment uncertainty shall consist of the uncertainty in the location of the docking interface calibration readout on the LEM side of the interface. This alignment uncertainty shall be less than 5.4 milliradians (rms) about the LEM X (yaw) axis.

3.3.2.1.5 LEM Structural Alignment

The LEM structural alignment uncertainty shall include the LEM structural manufacturing and flexing uncertainties between the docking interface and the LEM navigation base structural mounting surfaces. The random components of this alignment uncertainty shall be less than 3.0 milliradians (rms) about the LEM Y (pitch) axis, 3.0 milliradians (rms) about the LEM Z (roll) axis, and 1.5 milliradians (rms) about the LEM X (yaw) axis. The bias (systematic) components of this alignment uncertainty shall be less than 0.5 milliradians about the LEM X and Z axes and less than 1.0 milliradians about the LEM Y axis.

3.3.2.1.6 LEM Navigation Base Alignment

The LEM navigation base alignment uncertainty shall include the LEM navigation base structural mounting surface to LEM stub member alignment uncertainty including LGC readout. This alignment uncertainty shall be less than 0.5 milliradians (rms) about each of the LEM orthogonal axes.

REVISIONS A,B,C

MH01-05076-414

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NR.	6-16-65
	GAEC	
D. G. Hoag	MIT	16 Aug 65

INTERFACE CONTROL DOCUMENT

DR BY	G.A. Fatton	6-10-65
CHK BY		

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

LM/CSM Guidance and Navigation
(IMU Alignment)

TDRR 37444 MAR 28 1969

CODE IDENT NO.	SIZE	
03953	A	MH01-05076-414

SHEET 1 OF 10

Form M 110-N-57 Rev 4-63

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REVISIONS A,B,C

		LM-3 & SUBS	
V 36-3	V36-000002	COMMAND MODULE 98, 101-112	SID 64-1345, 1347
MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC

EFFECTIVITY AND SPECIFICATIONS

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SHEET 2 of 10

FORM M 110-N-8 NEW 4-63

REVISIONS

SYM	DESCRIPTION	REQD	REP	DATE	APPROVED
A	1. Effectivity Block added on page 2. 2. Para. 1.1 "SID" was changed to "NAA". 3. Para. 3.2.2 "will be" was changed to "are". 4. Para. 3.3.2.1.3 changed 7.2 to 11.2		GAC NAA	[illegible] [illegible]	[illegible] W. [illegible]
B	ADD GAEC LEM EFFECTIVITY		GAEC NAA MIT	2/2/66 2/2/66 7 Apr 66	RD Ram[illegible] [illegible] W. Stameris
C	1. Deleted LM-1 effectivity by IRN 6035. 2. Page 4 North American Rockwell Corp. Space Division WAS: North American Aviation, Inc. Space & Information Division 3. Page 5, Para. 2.1.1. Lunar Module Performance & Interface Specification Block II WAS Apollo Lunar Excursion Module Performance & Interface Specification. 4. Para. 2.1.2 - CM/LM Structural Interfaces, GAEC-NR WAS CM-LEM Structural Interface. 5. Change LEM to LM, as may places as it may occur in this ICD. 6. Figure 1, Page 7 - Added: $-Z_C$ (Yaw) Added: Subscripts, C = CSM & E = LM $+Z_E$ WAS +Z LEM $+Y_C$ (Pitch) WAS +Y CSM $+Y_E$ (Pitch) WAS +Y LEM $+Z_C$ (Yaw) WAS +Z CSM Deleted Note: See Figure 1 & 2 of ICD MH01-05057-416, CSM/LM Docking Aids, for relationships between vehicle axes and overall vehicle characteristics. 7. Page 9, Para. 3.3.2.1.4 - CM WAS LEM 8. Page 9, Para. 3.3.2.1.4.1 - LM WAS CM 9. Page 9, Para. 3.3.2.1.4.2 - CM WAS LEM		NR GAEC MIT	1-17-69 28 Jan 69	[illegible] W. Stameris

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CODE IDENT NO.	SIZE	
03953	A	TDRR 37444 MAR 28 1969 MH01-05076-414

SHEET 3 of 10

REVISIONS A,B,C

NOTES: (Unless Otherwise Specified)

This document represents agreement between the following organizations:

(a) North American Rockwell Corp.
Space Division
Downey, California

(b) Grumman Aircraft Engineering Corporation
Bethpage, Long Island
New York

(c) Massachusetts Institute of Technology
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CODE IDENT NO.	SIZE	
03953	A	TDRR 37444 MAR 28 1969 MH01-05076-414

SHEET 4 of 10

1.0 SCOPE

1.1 This document represents MF/GAEC/MIT agreements for performance, test, and qualification of the CSM/LM interfaces pertaining to IMU alignment for Block II Apollo missions.

2.0 APPLICABLE DOCUMENTS

2.1 **Specifications and Documentation**

2.1.1 **Specifications**

LSP 62-1244, Lunar Module Performance & Interface Specification, Block II

2.1.2 **Documents**

The following ICD's are either affected by the data in this ICD, or provide supporting data for this ICD.

LID-340-10008 AOT Field of View

MH01-05053-416 CSM/LM Docking Ground Rules

MH01-05128-116 CSM/LM Structural Interfaces, GAEC-NR

MH01-05057-416 CSM/LM Docking Aids

2.2 **Coordination Agreements and Correspondence**

Minutes of NASA Coordination Meeting with Massachusetts Institute of Technology and Grumman Aircraft Engineering Corporation, Meeting Number L7A, dates 25, 26 June 1964.

2.2.2 **Correspondence** (For reference only)

NASA TWX No. PS5/T1688-64-1565, (NAA Log No. W12695MA), dated 1 December 1964. (Establishes CSM/LEM docking alignment.)

2.3 **Applicable Dates**

Unless specific revision dates are given, the latest document and/or revision date is applicable

---

3.0 REQUIREMENTS

3.1 **Purpose**

The purpose of this document is to define the CSM/LM interface characteristics required to assure proper LM IMU alignment when the CSM and LM are attached.

3.2 **Mission Requirements**

3.2.1 **LM IMU Coarse Alignment Prior to Separation**

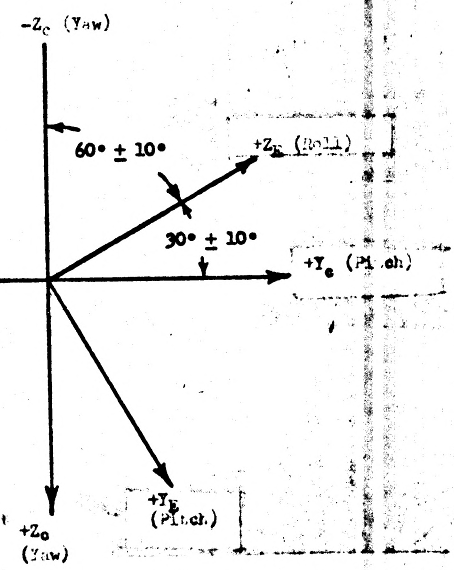
The initial coarse alignment of the LM IMU in lunar orbit will be performed prior to LM separation from the CSM. This alignment will be performed by orienting the LM IMU gimbals with reference to the CSM IMU gimbals. Data on the orientation of the CSM IMU gimbals will be transferred to the LM over the voice link.

3.2.2 **LM IMU Alignment Prior to Use of LM Backup Propulsion**

The LM propulsion system will be capable of performing backup thrusting for earth/moon midcourse corrections and transearth injection within the constraints of fuel availability. Prior to such operations it will be necessary to both coarse and fine align the LM IMU with the vehicles attached.

3.3 **Alignment Criteria**

The LM and CSM will be docked with their relative axis orientation as defined in ICD MH01-05057-416, Docking Aides paragraph number 3.1.2. This orientation results in the X (roll) axis of the CM being aligned with the X (yaw) axis of the LM. The positive X axis of the CM will be in the direction of the negative X axis of the LM. The LM positive Z (roll) axis will align 60 degrees plus or minus 10 degrees from the CSM negative Z (yaw) axis and 30 degrees plus or minus 10 degrees from the CSM plus Y (pitch) axis. (See Figure 1). If any discrepancies exist between this paragraph and ICD MH01-05057-416 the referenced ICD will be the governing document.



CSM positive X direction into page.

LM positive X (yaw) direction out of page.

Vehicle and Navigation Base Axes With LM and CSM in Docked Positions (Looking from CSM to LEM)

Figure 1

Subscripts

C = CSM
E = LM

3.3.1 **IMU Mounting Orientation**

In both the CM and the LM, the IMU's will be mounted such that the IMU reference axes are parallel to and have the same polarity as the vehicle axes. For zero gimbal angles, the gimbal axes will be aligned such that the outer gimbal axis shall have the same direction and polarity as the vehicle X axis, the middle gimbal axis shall have the same direction and polarity as the vehicle Z axis, and the inner gimbal axis shall have the same direction and polarity as the vehicle Y axis.

3.3.2 **Total Coarse Alignment Uncertainty**

The uncertainty in the LM IMU alignment with respect to desired inertial coordinates at the completion of the coarse align function described in paragraph 3.2.1 above shall be less than 20 milliradians (rms) about the LM Y (pitch) and Z (roll) axes and less than 40 milliradians (rms) about the LM X (yaw) axis. The LM X (yaw), Y (pitch), and Z (roll) axes shall be as shown in figure 1 of this ICD, and figure 1 of ICD MH01-05057-416.

3.3.2.1 **Coarse Alignment Uncertainty Components**

The total coarse alignment uncertainty shall consist of the significant components identified in the following paragraphs.

3.3.2.1.1 **CM Navigation Base Alignment**

The CM navigation base alignment uncertainty shall include the CM stable member uncertainty within 60 minutes of the last fine alignment, CM stable member to navigation base uncertainty including CGC readout, and the CM navigation base to structural mounts uncertainty. This alignment uncertainty shall be less than 3 milliradians (rms) about each of the LM orthogonal axes.

3.3.2.1.2 **Manual Transfer of Alignment Angles**

The manual transfer of alignment angle uncertainty shall include the resolution of the data transferred from the CM G&N to the LM G&N and the uncertainty in the exact orientation of the vehicle at the time when the data are transferred. This alignment uncertainty shall be less than 0.58 milliradians (rms) about each of the LM orthogonal axes.

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3.3.2.1.3 CM Structural Alignment

The CM structural alignment uncertainty shall include the CM navigation base structural mounting surfaces manufacturing alignment uncertainty and the CM structural flexing uncertainty. For the Y (pitch) and Z (yaw) axes, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the docking interface. The docking surface alignment uncertainty shall include parallelism and non-uniformity of the CM docking interface. For the X (roll) axis, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the LET structural mounting surfaces. Also included for the X (roll) axis, is the structural flexing between the LET structural mounting surfaces and the docking interface. The alignment uncertainty shall have a randomly distributed component of less than 11.2 milliradians, rms about each of the LM orthogonal axes. In addition, there shall be bias components of less than 4.1 milliradians about the LM Y (pitch) axis, 4.4 milliradians about the LM Z (roll) axis, and 0.9 milliradians about the LM X (yaw) axis.

3.3.2.1.4 Docking Interface Roll Calibration Alignment

The docking interface alignment uncertainty shall include the hard docking interface alignment uncertainty in pitch and yaw. In roll, the relative orientation of the two vehicles shall be determined from calibrations on the CM docking ring and a calibration marker on the LM docking ring, as shown in ICD MH01-05128-414, CM/LEM Structural Interface. The following two subsections define the CM and LM components of the roll calibration alignment.

3.3.2.1.4.1 LM Roll Calibration Alignment

The alignment uncertainty of the calibration marker on the LM docking ring shall consist of the alignment of the marker with respect to the LM Y and Z axes.

This alignment uncertainty shall be less than 1.2 milliradians (rms) about the CM X (roll) axis.

3.3.2.1.4.2 CM Roll Calibration Alignment

The CM docking interface calibration alignment uncertainty shall consist of the uncertainty in the location of the docking interface calibration readout on the CM side of the interface. This alignment uncertainty shall be less than 5.4 milliradians (rms) about the CM X (roll) axis.

REVISIONS A,B,C

3.3.2.1.5 LM Structural Alignment

The LM structural alignment uncertainty shall include the LM structural manufacturing and flexing uncertainties between the docking interface and the LM navigation base structural mounting surfaces. The random components of this alignment uncertainty shall be less than 3.0 milliradians (rms) about the LM Y (pitch) axis, 3.0 milliradians (rms) about the LM Z (roll) axis, and 1.5 milliradians (rms) about the LM X (yaw) axis. The bias (systematic) components of this alignment uncertainty shall be less than 0.5 milliradians about the LM X and Z axes and less than 1.0 milliradians about the LM Y axis.

3.3.2.1.6 LM Navigation Base Alignment

The LM navigation base alignment uncertainty shall include the LM navigation base structural mounting surface to LM stable member alignment uncertainty including LGC readout. This alignment uncertainty shall be less than 0.5 milliradians (rms) about each of the LM orthogonal axes.

REVISIONS

TDRR 22047 AUG 3 1 1965

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APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NAA	6-16-65
	GAEC	6/16/65
D. G. Hoag	MIT	16 Aug 65

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DR BY	G.A. Fatton 6-10-65
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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

LEM/CSM Guidance and Navigation
(IMU Alignment)

CODE IDENT NO.	SIZE	
03953	A	MH01-05076-414

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Form M 110-N-57 Rev 4-63

REVISIONS

MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC

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CODE IDENT NO.	SIZE	
03953	A	MH01-05076-414

SHEET 2 of 10

FORM M110-N-58 NEW 4-63

REVISIONS

SYM	DESCRIPTION	REQD	REP	DATE	APPROVED

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FORM M110-N-58 NEW 4-63

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REVISIONS

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SHEET 4 of 10

1.0 SCOPE

1.1 This document represents SID/GAEC/MIT agreements for performance, test, and qualification of the CSM/LEM interfaces pertaining to IMU alignment for Block II Apollo missions.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications and Documentation

2.1.1 Specifications

SID 62-1244, Apollo Lunar Excursion Module Performance and Interface Specification.

2.1.2 Documents

The following ICD's are either affected by the data in this ICD, or provide supporting data for this ICD.

MH01-05138-414 CSM/LEM Lunar Mission Definition

LID-340-10008 AOT Field of View

MH01-05053-416 CSM/LEM Docking Ground Rules

MH01-05128-116 CM-LEM Structural Interface

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2.3 Applicable Dates

Unless specific revision dates are given, the latest document and/or revision date is applicable

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3.0 REQUIREMENTS

3.1 Purpose

The purpose of this document is to define the CSM/LEM interface characteristics required to assure proper LEM IMU alignment when the CSM and LEM are attached.

3.2 Mission Requirements

3.2.1 LEM IMU Coarse Alignment Prior to Separation

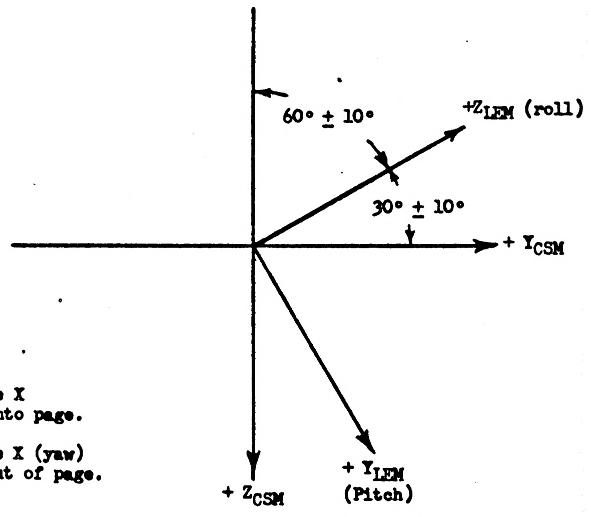
The initial coarse alignment of the LEM IMU in lunar orbit will be performed prior to LEM separation from the CSM. This alignment will be performed by orienting the LEM IMU gimbals with reference to the CSM IMU gimbals. Data on the orientation of the CSM IMU gimbals will be transferred to the LEM over the voice link.

3.2.2 LEM IMU Alignment Prior to Use of LEM Backup Propulsion

The LEM propulsion system will be capable of performing backup thrusting for earth/moon midcourse corrections and transearth injection within the constraints of fuel availability. Prior to such operations it will be necessary to both coarse and fine align the LEM IMU with the vehicles attached. Attitude constraints imposed upon the CSM during these functions will be controlled by ICD MH01-05138-414, CSM/LEM Lunar Design Mission.

3.3 Alignment Criteria

The LEM and CSM will be docked with their relative axis orientation as defined in ICD MH01-05057-416, Docking Aides paragraph number 3.1.2. This orientation results in the X (roll) axis of the CM being aligned with the X (yaw) axis of the LEM. The positive X axis of the CM will be in the direction of the negative X axis of the LEM. The LEM positive Z (roll) axis will align 60 degrees plus or minus 10 degrees from the CSM negative Z (yaw) axis and 30 degrees plus or minus 10 degrees from the CSM plus Y (pitch) axis. (See Figure 1). If any discrepancies exist between this paragraph and ICD MH01-05057-416 the referenced ICD will be the governing document.



CSM positive X direction into page.

LEM positive X (yaw) direction out of page.

NOTE: See Figures 1 and 2 of ICD MH01-05057-416, CSM/LEM Docking Aids, for relationships between vehicle axes and overall vehicle characteristics.

Vehicle and Navigation Base Axes
With LEM and CSM in Docked
Positions (Looking from CSM to LEM)

Figure 1

3.3.1 IMU Mounting Orientation

In both the CM and the LEM, the IMU's will be mounted such that the IMU reference axes are parallel to and have the same polarity as the vehicle axes. For zero gimbal angles, the gimbal axes will be aligned such that the outer gimbal axis shall have the same direction and polarity as the vehicle X axis, the middle gimbal axis shall have the same direction and polarity as the vehicle Z axis, and the inner gimbal axis shall have the same direction and polarity as the vehicle Y axis.

3.3.2 Total Coarse Alignment Uncertainty

The uncertainty in the LEM IMU alignment with respect to desired inertial coordinates at the completion of the coarse align function described in paragraph 3.2.1 above shall be less than 20 milliradians (rms) about the LEM Y (pitch) and Z (roll) axes and less than 40 milliradians (rms) about the LEM X (yaw) axis. The LEM X (yaw), Y (pitch), and Z (roll) axes shall be as shown in figure 1 of this ICD, and figures 1 and 2 of ICD MH01-05057-416, Docking Aides.

3.3.2.1 Coarse Alignment Uncertainty Components

The total coarse alignment uncertainty shall consist of the significant components identified in the following paragraphs.

3.3.2.1.1 CM Navigation Base Alignment

The CM navigation base alignment uncertainty shall include the CM stable member uncertainty within 60 minutes of the last fine alignment, CM stable member to navigation base uncertainty including CGC readout, and the CM navigation base to structural mounts uncertainty. This alignment uncertainty shall be less than 3 milliradians (rms) about each of the LEM orthogonal axes.

3.3.2.1.2 Manual Transfer of Alignment Angles

The manual transfer of alignment angle uncertainty shall include the resolution of the data transferred from the CM G&N to the LEM G&N and the uncertainty in the exact orientation of the vehicle at the time when the data are transferred. This alignment uncertainty shall be less than 0.58 milliradians (rms) about each of the LEM orthogonal axes.

3.3.2.1.3 CM Structural Alignment

The CM structural alignment uncertainty shall include the CM navigation base structural mounting surfaces manufacturing alignment uncertainty and the CM structural flexing uncertainty. For the Y (pitch) and Z (yaw) axes, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the docking interface. The docking surface alignment uncertainty shall include parallelism and non-uniformity of the CM docking interface. For the X (roll) axis, the alignment uncertainty is between the CM navigation base structural mounting surfaces and the LET structural mounting surfaces. Also included for the X (roll) axis, is the structural flexing between the LET structural mounting surfaces and the docking interface. The alignment uncertainty shall have a randomly distributed component of less than 7.2 milliradians, rms about each of the LEM orthogonal axes. In addition, there shall be bias components of less than 4.1 milliradians about the LEM Y (pitch) axis, 4.4 milliradians about the LEM Z (roll) axis, and 0.9 milliradians about the LEM X (yaw) axis.

3.3.2.1.4 Docking Interface Roll Calibration Alignment

The docking interface alignment uncertainty shall include the hard docking interface alignment uncertainty in pitch and yaw. In roll, the relative orientation of the two vehicles shall be determined from calibrations on the LEM docking ring and a calibration marker on the CM docking ring, as shown in ICD MH01-05128-414, CM/LEM Structural Interface. The following two subsections define the CM and LEM components of the roll calibration alignment.

3.3.2.1.4.1 CM Roll Calibration Alignment

The alignment uncertainty of the calibration marker on the CM docking ring shall consist of the alignment of the marker with respect to the CM Y and Z axes.

This alignment uncertainty shall be less than 1.2 milliradians (rms) about the LEM X (yaw) axis.

3.3.2.1.4.2 LEM Roll Calibration Alignment

The LEM docking interface calibration alignment uncertainty shall consist of the uncertainty in the location of the docking interface calibration readout on the LEM side of the interface. This alignment uncertainty shall be less than 5.4 milliradians (rms) about the LEM X (yaw) axis.

3.3.2.1.5 LEM Structural Alignment

The LEM structural alignment uncertainty shall include the LEM structural manufacturing and flexing uncertainties between the docking interface and the LEM navigation base structural mounting surfaces. The random components of this alignment uncertainty shall be less than 3.0 milliradians (rms) about the LEM Y (pitch) axis, 3.0 milliradians (rms) about the LEM Z (roll) axis, and 1.5 milliradians (rms) about the LEM X (yaw) axis. The bias (systematic) components of this alignment uncertainty shall be less than 0.5 milliradians about the LEM X and Z axes and less than 1.0 milliradians about the LEM Y axis.

3.3.2.1.6 LEM Navigation Base Alignment

The LEM navigation base alignment uncertainty shall include the LEM navigation base structural mounting surface to LEM stable member alignment uncertainty including LGC readout. This alignment uncertainty shall be less than 0.5 milliradians (rms) about each of the LEM orthogonal axes.

E.O. 45-15?

REVISIONS-A-B

TDRR 25628

MH01-05174-414

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
W. R. White	NAA	9/10/65
D. G. Hoag	MIT	16 Sept 65
R Oldenburg for E. Stern	GAEC	9-7-65

INTERFACE CONTROL DOCUMENT

DR BY	L. SUSSER	8/26/65
CHK BY		

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

NOMENCLATURE, MARKINGS AND COLOR
(CM/LEM CONTROL AND DISPLAY STANDARDIZATION)

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS AND NOTHING HEREIN CONTAINED SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN ALL PARTIES AFFECTED

CODE IDENT NO.	SIZE	
03953	A	MH01-05174-414

SHEET OF 32

Form M 330-H-57 Rev. 4-63

REVISIONS A - B

MODEL	PART NO.	DESCRIPTION	APPLICABLE SPEC
V-36-3	V36-976016	Command Module Serial 98, 101 thru 112	SID 64-1347, SID 64-1345

EFFECTIVITY AND SPECIFICATIONS

INTERFACE CONTROL DOCUMENT

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CODE IDENT NO.	SIZE	
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SHEET 2

FORM M110-H-56 NEW 4-63

REVISIONS

SYM	DESCRIPTION	REQD	REP	DATE	APPROVED
A	Incorporated IRN 00772, 00837, 00840, 00841 and 00842		NAA	9/10/65	W. R. White
			GAEC	9-7-65	R Oldenburg
			MIT	16 Sept 65	D G Hoag
B	Added C/M Effectivity to page 2		NAA	12/20/65	W. [illegible]
			GAEC	12-15-65	R Oldenburg
			MIT	21 Dec 65	DG Hoag by W.E. [illegible]
	Deleted the words "test and qualification" on page 4 Delete Paragraphs 2.2.1 & 2.2.2. In Paragraph 2.3, Add N/A		NAA	12/20/65	W. [illegible]
			GAEC	12/21/65	E. Stern
			MIT	21 Dec 65	DG Hoag by W.E. [illegible]
	Abbreviation for degree(s) was DEG. Changed to DEG(S). Asterisk was moved to left of degree symbol. Page 12.		NAA	12/20/65	W. [illegible]
			GAEC	12/21/65	E. Stern
			MIT	21 Dec 65	DG Hoag by W.E. [illegible]

INTERFACE CONTROL DOCUMENT

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SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	SIZE	
03953	A	MH01-05174-414

SHEET 3

REVISIONS A - B

1.0 SCOPE

This document establishes the specific technical requirements and represents SID/GAEC/MIT agreements for performance and design of one interface between Apollo CM and LEM Control and Display Subsystems. This document will control the design of Nomenclature, Markings, and the selection of colors to be used within the respective CM/LEM Control and Display Subsystems.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications and Documents

2.1.1 NASA - N/A

2.1.2 Federal

FED-STD-595 - Colors

2.1.3 Military

MIL-STD-12B, Military Standard Abbreviations for use on Drawings and in Technical Type Publications.

2.1.4 Contractor - N/A

2.2 Coordination Agreements

INTERFACE CONTROL DOCUMENT

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SPACE and INFORMATION SYSTEMS DIVISION
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CODE IDENT NO.	SIZE	
03953	A	MH01-05174-414

SHEET 4

REV	
	GRUMMAN AIRCRAFT ENGINEERING CORPORATION **BETHPAGE, L. I., NEW YORK**
ICD NO. LIS-370-10004	TDRR 16647 FEB 18 1965 **INTERFACE CONTROL DOCUMENT**
	THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
Perry L Gardner	GAEC	1/8/65
Arnold B. Whitaker	GAEC	1/8/65
D. G. Hoag	MIT	9 Feb 65

PREPARED BY: H. Donnelly/S. Glasser	CHECKED: G. Henderson G Henderson 1/5/65

TITLE:

LGC-LEM ELECTRICAL INTERFACE

CCA NO.

REV	MODEL NUMBER	REV	MODEL NUMBER	REV	MODEL NUMBER

EFFECTIVITY

CODE IDENT NO.	SHEET	ICD NO.	REV
26512	SHEET 1 OF 39	LIS 370-10004	

INTERFACE CONTROL DOCUMENT

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
					GAEC		

TDRR 16647 FEB 18 1965

TDRR 16647 FEB 18 1965

KEY: Responsibility is identified herein as follows:

① Grumman Aircraft Engineering Corporation
Bethpage, L. I., New York

② Massachusetts Institute of Technology
Cambridge, Massachusetts

③ National Aeronautics and Space Administration
Manned Spacecraft Center

④ Design data to be supplied by:

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Section II: Interface Circuitry
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  Ckt. 3: D.C. Discrete Switching (DSKY RELAYS)
  Ckt. 4: Attitude Hand Controller
  Ckt. 5: RCS Jet Discretes
  Ckt. 6: Pulse Interface Circuit
  Ckt. 7: PCMTE Outputs
  Ckt. 8: PCMTE Serial Digital Data Input
  Ckt. 9: PCMTE 1024 kc Sync-Signal Input
  Ckt. 10: Radar Pulse Inputs
  Ckt. 11: Radar Pulse Outputs
  Ckt. 12: LEM Mission Programmer Command Word
  Ckt. 13: DSKY Illumination
  Ckt. 14: LGC Prime Power
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INTRODUCTION

This ICD defines the electrical signal interface between the LEM Guidance Computer (LGC), including the DSKY, and LEM Spacecraft subsystems. The interface through which spacecraft prime power is supplied to the LGC, and the LGC-DSKY interface (GAEC cabling) are included for reference only; defining documents are LIS-390-10002 and LID-390-10001, respectively.

This ICD is divided into four sub-sections. Section I is a tabulation which identifies the signals involved in the LGC-LEM interface and specifies their electrical characteristics as measured at the interface. For the purposes of this tabulation, the "0" condition is defined as that condition which normally yields the minimum r.m.s. current flow through a given wire of the interface, and the "1" condition is defined as that which normally yields the maximum r.m.s. current flow through a given wire of the interface. The nomenclature used in describing the pulse signal characteristics is defined in Figure 1. (Sheet27).

Section II identifies the electrical circuitry on either side of the interface to a degree sufficient to clarify the nature of the signals as measured at the interface. The interface circuit used for a given signal is indicated by the "REFERENCE CIRCUIT" column in the above tabulation, in which the circuit numbers of Section II are noted. The noise limits referred to for a given interface circuit are those which could be attained without affecting the proper functioning of the interface. As a general rule, however, the interference emanating from either side of the interface shall not exceed the limits specified in MIL-I-26600/ MSC-EMI-10A. The susceptibility of the respective equipments on either side of the interface shall meet the requirements of the same specifications.

Section III defines the time relationships required between signals for the transmission of digital data, at the interface. Waveform nomenclature is also defined in this section, as noted above.

Section IV identifies signals and signal returns with assigned pin numbers, wire sizes and shielding configuration at the interface. For those discrete interfaces for which a common voltage source is provided, the sizes of the isolation resistors are also noted. Note that the wiring and bundling configurations in this section are provided for information purposes only, the controlling document being LID-390-10001.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
A	CONTROL MODE AND STATUS SIGNALS														Note 1: Source impedance (switch closure) for all signals on this sheet includes LGC isolation resistor.
1.	Automatic Mode	I	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
2.	Attitude Hold Mode	I	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
3.	Out of Detent	P	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
4.	Start Abort Porgram	I	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
5.	Start Abort/Stage Program	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
6.	Engine Armed	2	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
7.	Digital Autopilot In Control	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
8.	In Auto Throttle	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
9.	Rate of Descent Bar	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Not Connected
10.	Rate of Descent Discrete	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Not Connected
11.	Rate of Descent Discrete	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Not Connected
12.	Display Inertial Data	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
13.	Horizontal Velocity Low Scale	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
14.	Block Uplink	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
15.	Thruster 2-4 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
16.	Thruster 5-8 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
17.	Thrusters 1-3 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
18.	Thrusters 6-7 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
19.	Thrusters 14-16 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
20	Thrusters 13-15 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
21.	Thrusters 9-12 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
22.	Thrusters 10-11 Fail	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
23.	Stage Verified (status)	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
24.	4 Jet Select (Pitch & Roll)	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22k	22K	Not Connected
25.	Mark X	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Switches located on/near
26	Mark Y	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	AOT; GAEC to provide
27	Mark Bar	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	inter-connecting wiring
28	Reject Mark	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
B	TRANSLATION HAND CONTROLLER														
1.	+ X Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	Source Impedance (Switch Closure) for translation commands includes LGC isolation resistor.
2.	- X Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
3.	+ Y Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
4.	- Y Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
5.	+ Z Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
6.	- Z Translation Command	1	28±11	0±2	-	-	-	-	-	-	3K	Open	22K	22K	
C	ATTITUDE HAND CONTROLLER														
1.	Pitch Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	④②	④②	④②	Hand Controller Signals are 800~ analog inputs to computer. See Ckt. 4 for signal characteristics.
2.	Roll Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	④①	④②	④②	
3.	Yaw Rate Command	4	-	-	-	-	-	-	-	-	2K@85°	④①	④②	④②	
D	MAIN ENGINE SIGNALS														
1.	Increase Throttle	6	-	-	7±3	3±1	20	4	0.2	3.2	100	10 (10mh.)	200	20 (20mh.)	Figure in parenthesis is inductance of transformer winding "seen" at interface
2.	Decrease Throttle	6	-	-	7±3	3±1	20	4	0.2	3.2	100	10 (10mh.)	200	20 (20mh.)	
3.	Engine On	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
4.	Engine Off	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
5.	+ Pitch Trim	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
6.	- Pitch Trim	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
7.	+ Roll Trim	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
8.	- Roll Trim	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
9.	Pitch Gimbal Off	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	Source Impedance includes LGC Isolation Resistor of 2000 ohms.
10.	Roll Gimbal Off	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	

INTERFACE CONTROL DOCUMENT	LGC-LEM ELECTRICAL INTERFACE	SHEET 7 OF 39	ICD NO. LIS 37-10004	REV -

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE. L. I., NEW YORK

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
E	RCS JET DISCRETES														
1.	RCS Jet #2 (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
2.	RCS Jet #6 (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
3.	RCS Jet #10 (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
4.	RCS Jet #14 (+X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
5.	RCS Jet #5 (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22k	
6.	RCS Jet #9 (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
7.	RCS Jet #1 (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
8.	RCS Jet #13 (-X)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
9.	RCS Jet #12 (+Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
10.	RCS Jet #16 (+Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
11.	RCS Jet #4 (-Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
12.	RCS Jet #8 (-Y)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
13.	RCS Jet #11 (+Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
14.	RCS Jet #7 (+Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
15.	RCS Jet #3 (-Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	
16.	RCS Jet #15 (-Z)	5	(0±2)	(28±11)	-	-	-	-	-	-	<3K	>500K	22K	22K	

INTERFACE CONTROL DOCUMENT

LGC-LEM ELECTRICAL INTERFACE

SHEET 8 OF 39

ICD NO. LIS 370-10004

REV

ENG 37.4 7-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE. L. I., NEW YORK

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
F	RENDEZVOUS RADAR SIGNALS														
1	RR in "1" (Data Flow)	11	-	-	7±3	4±2	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20(20mh)	See Sheet #28 for Digital Readout timing.
2	RR in "0" (Data Flow)	11	-	-	7±3	4±2	20	4	0.2	Digital Data at 3.2	100	10(10mh)	200	20 (20mh)	
3.	RR Reset Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	"Loads" in parenthesesare inductance of transformer winding "seen" at interface.
4.	RR Range Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
5.	RR Range Rate Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
6.	RR Counter Readout Command	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
7.	RR Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
8.	RR Power On & Auto Mode	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
9.	RR Range Low Scale	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
10.	Auto Angle Track Enable	3	④①	④①	-	-	-	-	-	-	Closure	Open	④①	④①	Relay in DSKY
G	LANDING RADAR SIGNALS														
1.	LR Reset Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	See Sheet 28 for Digital Readout timing.
2.	LR Range Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
3.	LR X_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	"Loads" in parentheses are inductance of transformer winding"seen" at interface.
4.	LR Y_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
5.	LR Z_A Velocity Gate Strobe	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
6.	LR Counter Readout Command	10	-	-	7±3	3±0.5	20	4	0.2	3.2	100	10(10mh)	200	20(20mh)	
7.	LR in "1" (Data Flow)	11	-	-	7±3	4±2.5	20	4	0.2	Digital Data at3.2	100	10(10mh)	200	20(20mh)	
8.	LR in "0" (Data Flow)	11	-	-	7±3	4±2.	20	4	0.2	Digital Data at3.2	100	10(10mh)	200	20(20mh)	
9.	LR Range Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22k	
10.	LR Antenna Position #1	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22k	

INTERFACE CONTROL DOCUMENT

LGC-LEM ELECTRICAL INTERFACE

SHEET 9 OF 39

ICD NO. LIS 370-10004

REV

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NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
G	Landing Radar Signals														
11.	LR Antenna Position #2 Indication	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
12.	LR Velocity Data Good	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
13.	LR Range Low Scale Factor	1	28±11	0±2	-	-	-	-	-	-	4K	Open	22K	22K	
14.	LR Antenna Position Command	3	④ ①	④ ①	-	-	-	-	-	-	Closure	Open	④ ①	④ ①	Relay in DSKY
H	Telemetry (Down Link)														
1.	Start Pulse	7	-	-	4.5±1	4±1	-	0	0.3	50pps	100	100	200	20(20mh)	See Sheet #30 for Digital Readout Timing.
2.	Stop Pulse	7	-	-	4.5±1	4±1	-	0	0.3	50pps	100	100	200	20(20mh)	
3.	Bit Sync Pulse	7	-	-	4.5±1	4±1	-	0	0.3	2 at 51.2	100	100	200	20(20mh)	40 pulses, 50 times/sec.
4.	Serial Digital Data	8	-	-	7±2	*	20	6	0.2	**	100	10(10mh)	500	500	
5.	Sync Signal	9	-	-	4 ±1	0.5±0.25	-	④ ①	0.2	1024	100	10(10mh)	100	100	Frequency Stability, ±2ppm.
NOTE:	* Same as Bit Sync Pulse ** As commanded by Bit Sync and Data														
I	Caution and Warning Signals														
1.	LGC (Warning)	3	④ ①	④ ①	-	-	-	-	-	-	Closure	Open	④ ①	④ ①	Relay in DSKY*
2.	PGNS (Caution)	3	④ ①	④ ①	-	-	-	-	-	-	Closure	Open	④ ①	④ ①	Relay in DSKY
3.	INRTL Ref (Warning)	3	④ ①	④ ①	-	-	-	-	-	-	Closure	Open	④ ①	④ ①	Relay in Dsky
NOTE:	* Closures shorter than ½ second should not cause an alarm indication for this discrete.														

NO.	SIGNAL IDENTIFICATION	REF. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE±10%		LOAD IMPEDANCE±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
J	LEM MISSION PROGRAMMER SIGNALS														
1.	Out "0" 1 (command word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	Repetition 6 words/sec max. Differential time for the appearance of all bits for the command word is 1ms. max
2.	Out "0"2 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
3.	Out "0"3 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
4.	Out "0"4 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
5.	Out "0"5 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
6.	Out "0"6 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000max.	-	250	2.2K	250	2.2K	
7.	Out "0"7 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
8.	Out "0"8 (Command Word)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
9.	Out "0" 12 (Enable)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	All "ones" indicate LMP word.
10.	Out "0" 13 (Enable)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
11.	Out "0" 14 (Enable)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
12.	Out "0" 15 (Enable)	12	10	13	-	$(24\pm\frac{6}{7})10^3$	-	-	3000 max.	-	250	2.2K	250	2.2K	
13.	Uplink Data Binary "1"	6	-	-	7±3	3±1	20	4	0.2	1	100	10(10mh)	200	20(20mh)	See Sheet 31 for uplink timing.
14.	Uplink Data Binary "0"	6	-	-	7±3	3±1	20	4	0.2	1	100	10*(10mh)	200	20(20mh)	
K	MONITOR SIGNALS														
1.	Monitor (+)	④①②													Not connected.
2.	Monitor (-)	④①②													Not Connected.

NO.	SIGNAL IDENTIFICATION	REP. CIRC.	D.C. "1"	D.C. "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP. RATE	SOURCE IMPEDANCE ±10% "1"	SOURCE IMPEDANCE ±10% "0"	LOAD IMPEDANCE ±10% "1"	LOAD IMPEDANCE ±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
L.	ALTITUDE METERS														
1.	Altitude "0"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10 (10mh.)	200	20 (20mh.)	See Sheet #32 for Altitude and Altitude Rate word timing.
2.	Altitude "1"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10 (10mh.)	200	20 (20mh.)	
3.	Altitude Rate "0"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10 (10mh.)	200	20 (20mh.)	
4.	Altitude Rate "1"	6	-	-	7±3	3±1	20	4	0.2	Digital Data at 3.2	100	10 (10mh.)	200	20 (20mh.)	
5.	Altitude Meter Sync	2	④①	④①	-	-	-	-	-	-	<3K	>500K	④①	④①	
M.	AGS SIGNALS														
1.	Crosslink "0" Out		-	-											Not connected. ④①②
2.	Crosslink "1" Out		-	-											Not connected.
3.	Crosslink "0" In		-	-											Not connected.
4.	Crosslink "1" In		-	-											Not connected
N.	DSKY ILLUMINATION														
1.	DSKY Dimmer	13	-	-	-	-	-	-	-	-	④②	④②	≤ 10K	≤ 10K	800 cps; See Sheet #25
2.	Controlled 400~	13	-	-	-	-	-	-	-	-	④①	④①	④②	④②	400 cps; See Sheet #[illegible]

NO.	SIGNAL IDENTIFICATION	REP. CIRC.	D.C. "1"	D.C. "0"	PULSE AMPL.	PULSE WIDTH	PULSE DROOP	PULSE BACKSW'G	PULSE RISE TIME	PULSE REP. RATE	SOURCE IMPEDANCE ±10% "1"	SOURCE IMPEDANCE ±10% "0"	LOAD IMPEDANCE ±10% "1"	LOAD IMPEDANCE ±10% "0"	REMARKS
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
O.	LGC-DSKY INTERFACE														
1.	Key Code 1	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	These signals are included for information purposes only. The signal sources and loads, with the exception of LMP interfaces, are GFE, but GAEC provides the interconnecting cables.
2.	Key Code 2	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
3.	Key Code 3	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
4.	Key Code 4	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
5.	Key Code 5	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
6.	KEBD RST	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
7.	Test AL'M	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
8.	ERR Light Reset	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
9.	Spare	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
10.	PWR Ret.	-	④ ②	④ ②	-	-	-	-	-	-	④ ②	④ ②	④ ②	④ ②	
11.	Out 0 - 1	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
12.	Out 0 - 2	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
13.	Out 0 - 3	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
14.	Out 0 - 4	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
15.	Out 0 - 5	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
16.	Out 0 - 6	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
17.	Out 0 - 7	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
18.	Out 0 - 8	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
19.	Out 0 - 9	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
20.	Out 0 - 10	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	* No LMP interface as listed here. See Sheet 11.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

NO.	SIGNAL IDENTIFICATION	REP. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
0	LGC-DSKY INTERFACE (CONT.)														NOTE * No LMP Interface as listed here See Sheet 11.
21.	OUT 0-11	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
22.	OUT 0-12	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
23.	OUT 0-13	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
24.	Out 0-14	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
25.	Out 0-15	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	Also listed for LMP
26.	PGM Alarm	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
27.	Comp Act.	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
28.	Tel. Alarm	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
29.	Restart	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
30.	RR Enable	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
31.	LR POS CMD	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
32.	Uplink ACT	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
33.	Key Release	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
34.	CRKT Alarm	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
35.	Timing 1	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
36.	Timing 2	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
37.	Power Sync.	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
38.	SPARE 1	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
39.	SPARE 2	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
40.	Spare 3	12*	10	13	-	-	-	-	-	-	<3K	>500K	250	2.2K	
41.	DSKY GND	1	-	-	-	-	-	-	-	-	-	-	-	-	Interfaces LMP (Ckt-12)
42.	+3v.	-	-	-	-	-	-	-	-	-	-	-	-	-	
43.	+13V.	-	-	-	-	-	-	-	-	-	-	-	-	-	Interfaces LMP (Ckt-12)
44.	+28v.	-	-	-	-	-	-	-	-	-	-	-	-	-	

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BETHPAGE, L. I., NEW YORK

NO.	SIGNAL IDENTIFICATION	REP. CIRC.	D.C.		PULSE						SOURCE IMPEDANCE ±10%		LOAD IMPEDANCE ±10%		REMARKS
			"1"	"0"	AMPL.	WIDTH	DROOP	BACKSW'G	RISE TIME	REP. RATE	"1"	"0"	"1"	"0"	
			VOLTS	VOLTS	VOLTS	MICROSEC.	%	VOLTS	MICROSEC	KPPS	OHMS	OHMS	OHMS	OHMS	
P	LGC POWER INPUTS														
1.	Bus A HI	14	-	-	-	-	-	-	-	-	④①	④①	④②	④②	
2.	Bus A Low	14	-	-	-	-	-	-	-	-	④①	④①	④②	④②	See Sheet No. 26
3.	Bus B Hi	14	-	-	-	-	-	-	-	-	④①	④①	④②	④②	Input circuitry included for for information only. This interface is controlled by ICD # LIS 390-10002
4.	Bus B Low	14	-	-	-	-	-	-	-	-	④①	④①	④②	④②	

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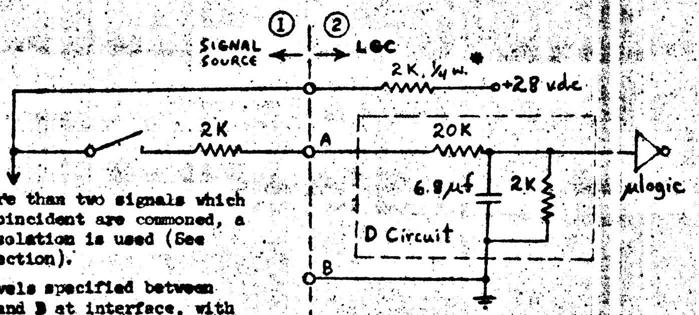
SECTION II

Circuit 1: D.C. Discrete Switching (Manual or Relay)


①
②
SIGNAL SOURCE
LGC
2K, ¼ w. *
+28 vdc
2K
A
20K
6.8 µf
2K
µlogic
D Circuit
B

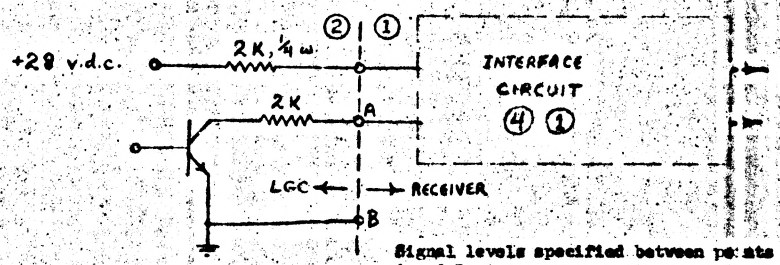
*Where more than two signals which may be coincident are commoned, a 1 kohm isolation is used (See wiring section).

Signal levels specified between points A and B at interface, with point B the reference level.

Noise Limits:

1. Switch closed ("1"): Maximum noise amplitude -50v., if noise pulse does not exceed 0.5 millisecond width at maximum repetition rate of 50 pps.
2. Switch open ("0"): Maximum noise amplitude +50v., if noise pulse does not exceed 1 millisecond width at maximum repetition rate of 50 pps.

Circuit 2: D.C. Discrete Switching (Solid State Switch)


+28 v.d.c.
2K, ¼ w.
②
①
2K
A
INTERFACE CIRCUIT
④ ①
LGC
RECEIVER
B

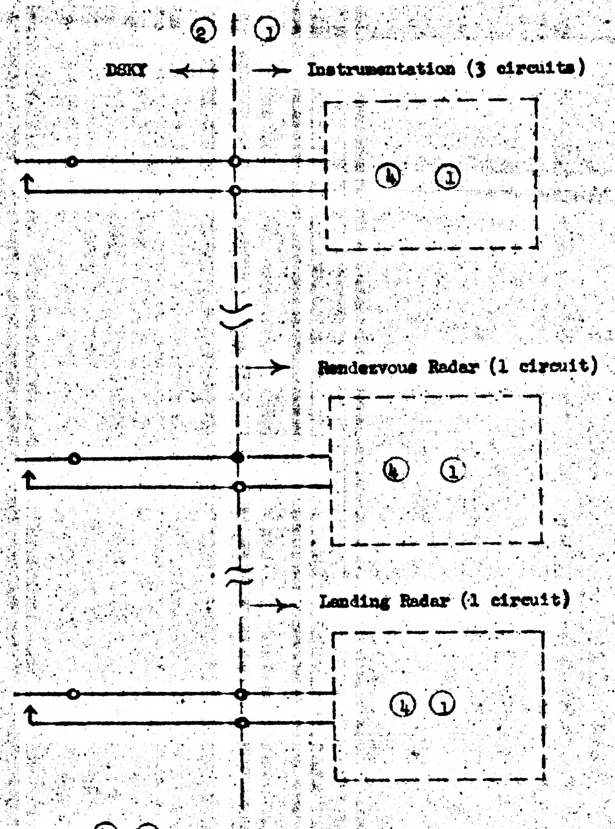
Signal levels specified between points A and B at interface, with point B the reference level.

Amplitude "1"; source impedance less than 3K., $I_c = 5$ ma., maximum.
Amplitude "0"; source impedance greater than 500K., V=40 v.d.c. maximum.

Noise Limits: As specified for Circuit 1, above.

SECTION II

Circuit 3: D.C. Discrete Switching (DSKY Relay)

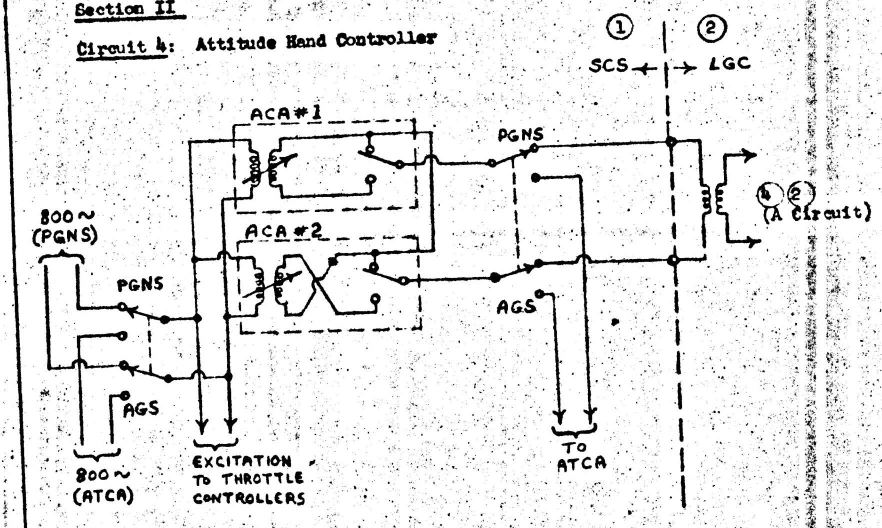

②
①
DSKY
Instrumentation (3 circuits)
④ ①
Rendezvous Radar (1 circuit)
④ ①
Landing Radar (1 circuit)
④ ①

Relay Type: ④ ②

Switch will be closed to indicate signal present. Maximum switch current; ½ amp.

Section II

Circuit 4: Attitude Hand Controller


①
②
SCS
LGC
ACA#1
ACA#2
PGNS
AGS
④② (A Circuit)
800~ (PGNS)
PGNS
AGS
800~ (ATCA)
EXCITATION TO THROTTLE CONTROLLERS
TO ATCA

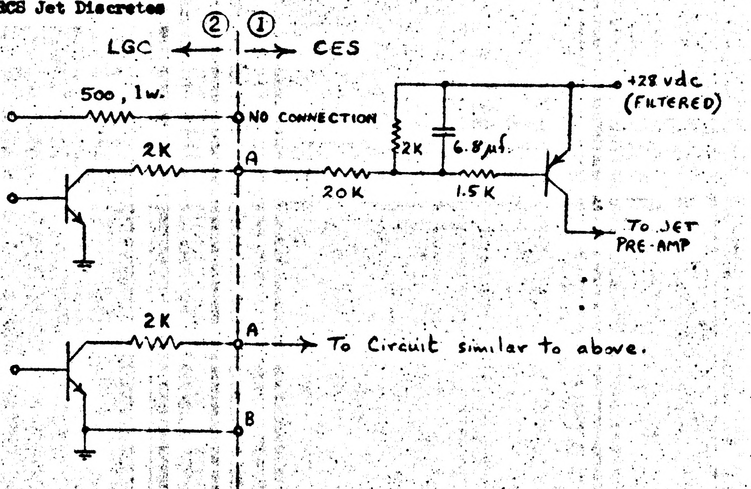
Out of detent indication 3/4° ± 1/4°.
Null voltage 30 mv. RMS. Max., load 20 Kohm.
Quadrature 10 mv. RMS max., load 20 Kohm.
Scale factor 2.8 volts ± 0.14 volts RMS at 11° hand controller position, load 20 Kohm.
Source impedance, 2 K at 85°
Rate Command 7.15 degrees/sec - volt RMS.
800 cps excitation (PGNS 800 cps).
Phase shift 0-10° maximum into 20 Kohm load.
In-phase output corresponds to positive rate command.
Linearity 5%

A Circuit:

Linearity ± 10%, $\frac{1}{2}° < \theta < 12°$
Quantization 32 states/12° (3/8°)
Load impedance, non linear ④② ohms.
Sample rate, ④①②

SECTION II

Circuit 5: RCS Jet Discretes


②
①
LGC
CES
500, 1w.
NO CONNECTION
+28 vdc (FILTERED)
2K
A
2K
6.8 µf.
20K
1.5K
To JET PRE-AMP
2K
A
To Circuit similar to above.
B

16 Drive Signals use similar circuits with common 28v. (filtered) source.

All measurements made between points A and B; B Reference.

Amplitude "1"; source impedance less than 3K, $I_c = 5$ ma. maximum.

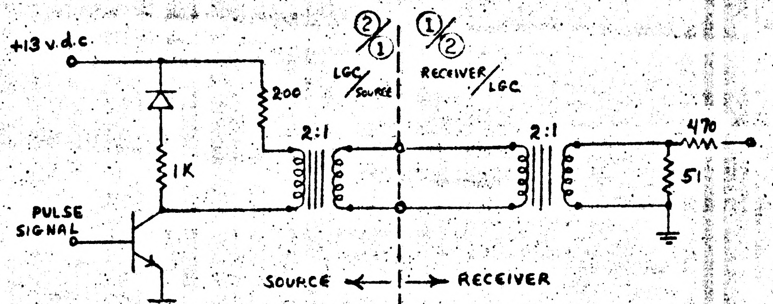
Amplitude "0"; source impedance greater than 500K, V = 40 vdc. maximum.

Noise Limits

Same as for Circuit 1, above.

SECTION II

Circuit 6: Pulse Interface Circuit


+13 v.d.c.
200
1K
PULSE SIGNAL
2:1
②/① LGC/SOURCE
①/② RECEIVER/LGC
2:1
470
51
SOURCE ← → RECEIVER

Transformers specified by NASA drawing #1006762.

Presence of pulse(s) shall indicate "on" ("1") condition.

Absence of pulse(s) shall indicate "off" ("0") condition.

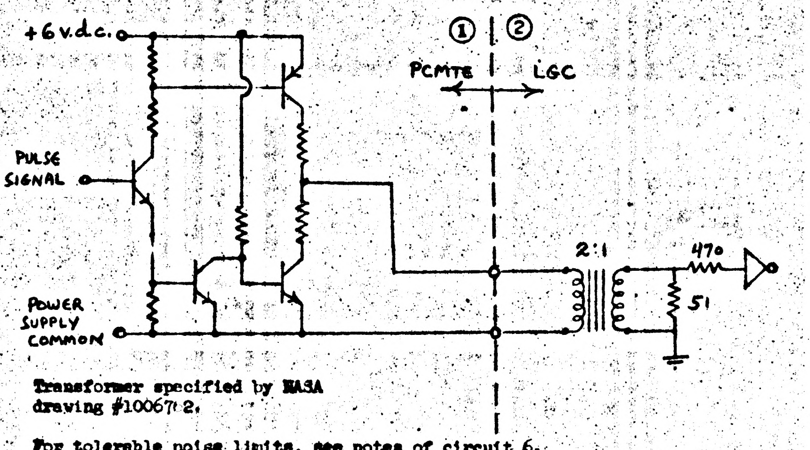
Noise Limits:

1. During the "on" condition, the signal plus noise shall remain within the envelope defined by the parameters for the interface signal given in Section I.

2. During the "off" condition, the noise shall remain within the envelope defined by the upper limit of +0.4v., and lower limit -4.0v., measured with respect to the Amplitude Reference level.

SECTION II

Circuit 7: PCMTE Outputs


+6 v.d.c.
PULSE SIGNAL
POWER SUPPLY COMMON
① ②
PCMTE LGC
2:1
470
51

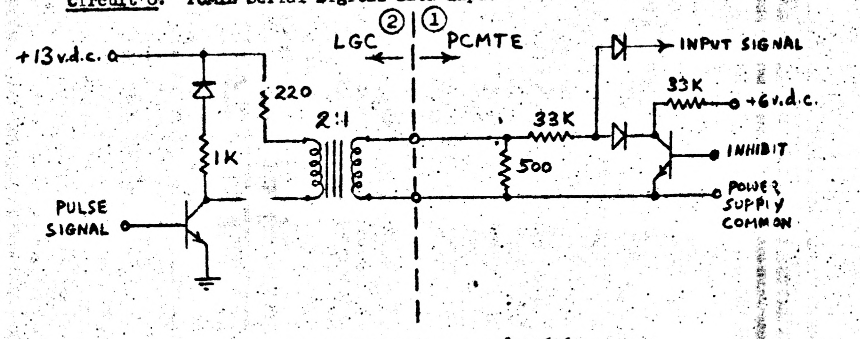
Transformer specified by NASA drawing #1006762.

For tolerable noise limits, see notes of circuit 6.

Levels specified on signal listing measured at PCMTE with 200Ω resistive load.

SECTION II

Circuit 8: PCMTE Serial Digital Data Input

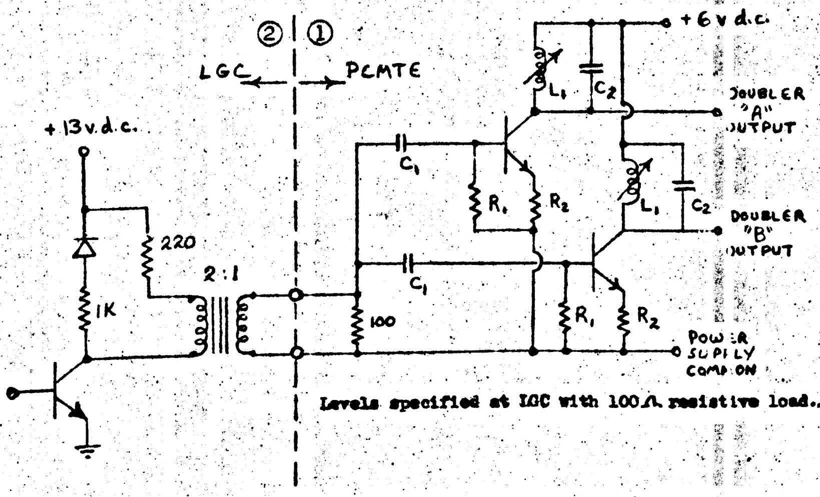

+13 v.d.c.
220
1K
PULSE SIGNAL
2:1
② ①
LGC PCMTE
33K
500
33K
INPUT SIGNAL
+6 v.d.c.
INHIBIT
POWER SUPPLY COMMON

Transformer specified by NASA drawing #1006762.

Levels specified at LGC with 500Ω resistive load.

For tolerable noise limits, see notes of circuit 6.

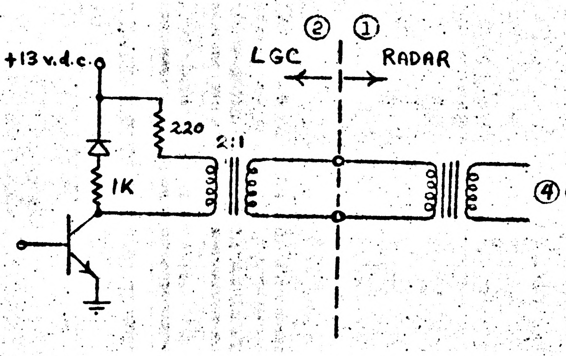
Circuit 9: PCMTE 1024 kc. Sync Signal Input


② ①
LGC PCMTE
+13 v.d.c.
220
1K
2:1
100
C₁
R₁
R₂
C₁
L₁
C₂
L₁
C₂
R₁
R₂
+6 v d.c.
DOUBLER "A" OUTPUT
DOUBLER "B" OUTPUT
POWER SUPPLY COMMON

Levels specified at LGC with 100Ω resistive load.

SECTION II

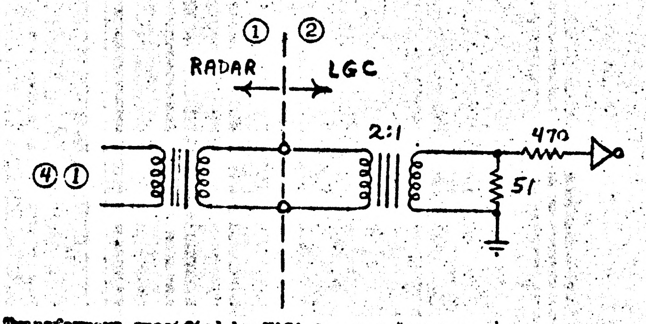
Circuit 10: Radar Pulse Inputs


+13 v.d.c.
② ①
LGC RADAR
220
2:1
1K
④①

Transformers specified by NASA drawing #1006762.

For tolerable noise limits, see notes of circuit 6.

Circuit 11: Radar Pulse Outputs

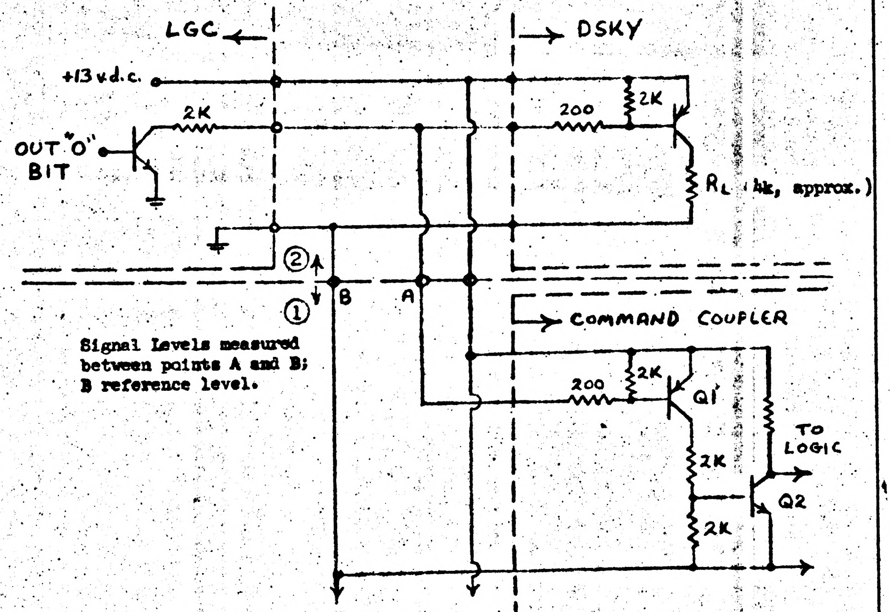

① ②
RADAR LGC
④①
2:1
470
51

Transformers specified by NASA drawing #1006762

For tolerable noise limits, see notes of circuit 6.

SECTION II

Circuit 12: LEM Mission Programmer Command Word.


LGC
DSKY
+13 v.d.c.
2K
OUT "O" BIT
200
2K
R_L (4k, approx.)
②
①
B
A
COMMAND COUPLER
200
2K
Q1
2K
2K
TO LOGIC
Q2

Signal Levels measured between points A and B; B reference level.

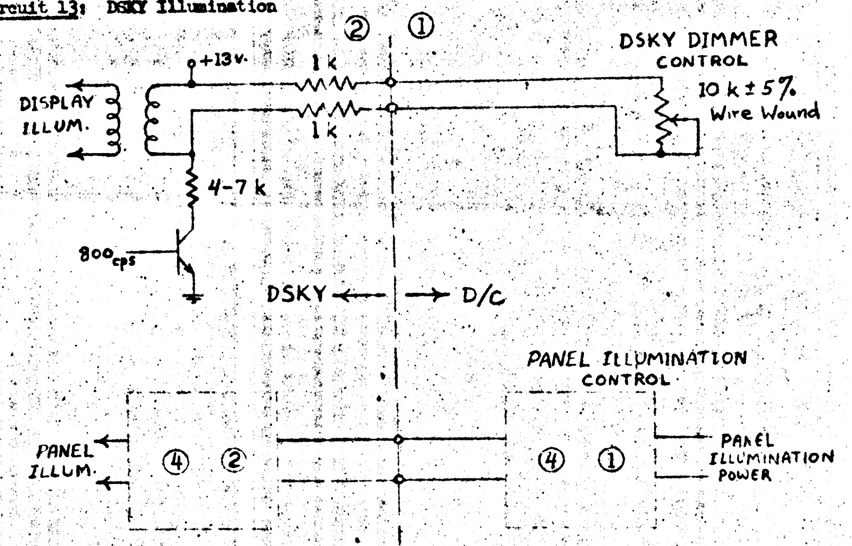
LGC ground may not be tied to Command Coupler ground.

LGC +13 volts may not be connected except as shown.

Circuit 12*, referenced for LGC-DSKY wiring, is as shown above, but with no command coupler interface.

SECTION II

Circuit 13: DSKY Illumination


②
①
+13v.
1k
1k
DSKY DIMMER CONTROL
10 k ± 5% Wire Wound
DISPLAY ILLUM.
4-7 k
800 cps
DSKY
D/C
PANEL ILLUMINATION CONTROL
PANEL ILLUM.
④ ②
④ ①
PANEL ILLUMINATION POWER

Panel Illumination Power

Voltage 115v. ± 2.5 v. (controlled 20-75 volts. Emergency condition 115v.).

Current 1.75ma (input power not to exceed 0.66 watts at 75v.).

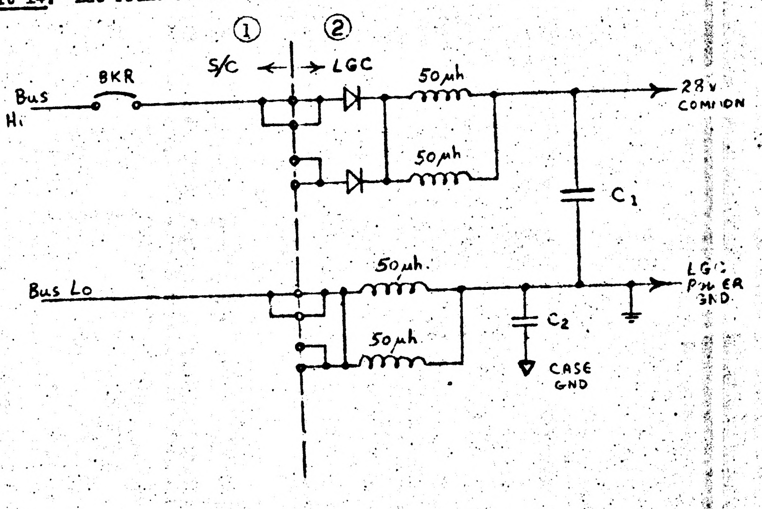
Frequency 400± 10 cps

Noise: Modulation per MIL STD 704
Transients - 225 v. max. peak, 25 msec. risetime, recovery to steady state within 50 msec.

Voltage spikes, superimposed on a.c., of 10v. max. amplitude with 90% recovery time within 250 µsec.

SECTION II

Circuit 14: LGC Prime Power (For reference only. See LIS 390-10002)


①
②
S/C
LGC
Bus Hi
BKR
50µh
50µh
28v COMMON
C_1
Bus Lo
50µh
50µh
C_2
LGC POWER GND
CASE GND

Prime Power Characteristics

(For reference only. See LIS-390-10002)

Voltage: ④ ①

Current: 4 amps max.

Standby Current: 0.5 amp.

Circuits

Diodes specified in NASA Dwg # ④ ②

Inductance specified in NASA Dwg # ④ ②

BKR. ④ ①

C_1 greater than ④ ②

C_2 greater than ④ ②

SECTION III-1

WAVEFORM DESCRIPTION

Pulse waveform nomenclature used in the tables of SECTION I is defined below:

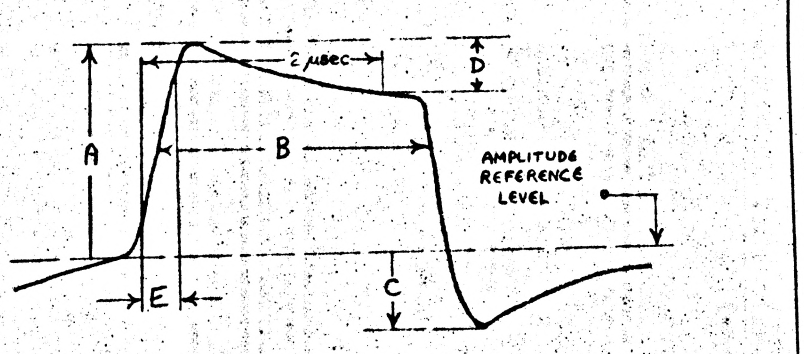

2 µsec
D
A
B
AMPLITUDE REFERENCE LEVEL
E
C

Figure 1

A. Amplitude-measured to pulse maximum positive level.

B. Pulse width-measured at A/2 level.

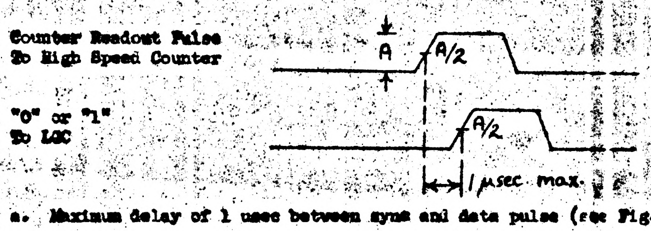
C. Backswing-measured to signal maximum negative level.

D. Droop-measured from pulse maximum positive level to level at 2 µsec.

E. Rise Time-time required for pulse to rise from 10% to 90% of A.

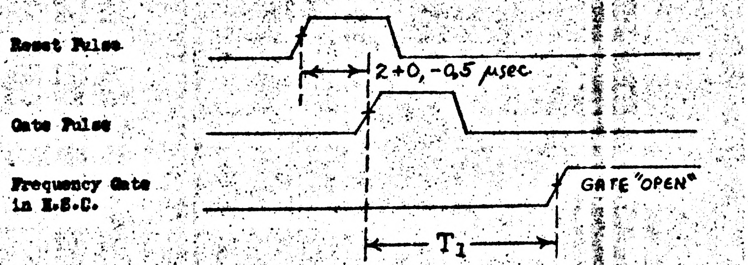
SECTION III-2

Radar Pulse Timing


Counter Readout Pulse
To High Speed Counter
A
A/2
"0" or "1"
To LGC
A/2
1 μsec max.

a. Maximum delay of 1 usec between sync and data pulse (see Fig. above).

b. The 15 sync pulses will generate 15 "0" or "1" pulses. The more significant bits will occur earlier in time. A "1" is represented as a pulse on the "1" line and a "0" as the presence of a pulse on the "0" line.


Reset Pulse
2+0, -0.5 μsec
Gate Pulse
Frequency Gate
in E.S.C.
GATE "OPEN"
T_1

c. Delay between first gate pulse and opening of frequency gate

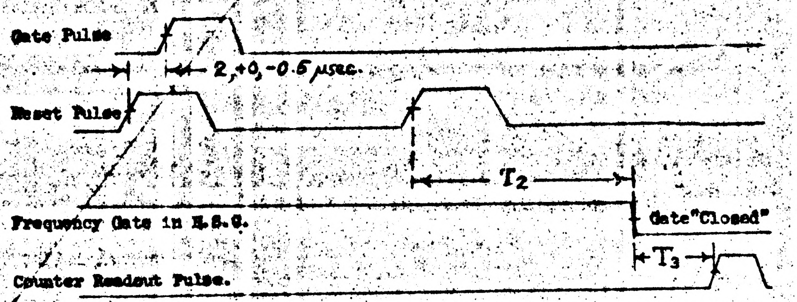
ER RANGE: T_1 = ④①② usec.± usec.

ER RANGE RATE: T_1 = ④①② usec.± usec.

LR RANGE: T_1 = ④①② usec.± usec.

LR Coordinate Velocities: T_1 = ④①② usec.± usec.

SECTION III-2


Gate Pulse
2, +0, -0.5 μsec.
Reset Pulse
T_2
Frequency Gate in E.S.C.
Gate "Closed"
T_3
Counter Readout Pulse.

d. Delay between reset pulse and closing of frequency counter gate:

T_2 = ④ ① ② μsec. ± μsec.

Gate closure to CRC pulse:

T_3 = ④ ① ② μsec. ± μsec.

$T_2 + T_3$ is approximately, 80 μ sec.

e. Counter gate length:

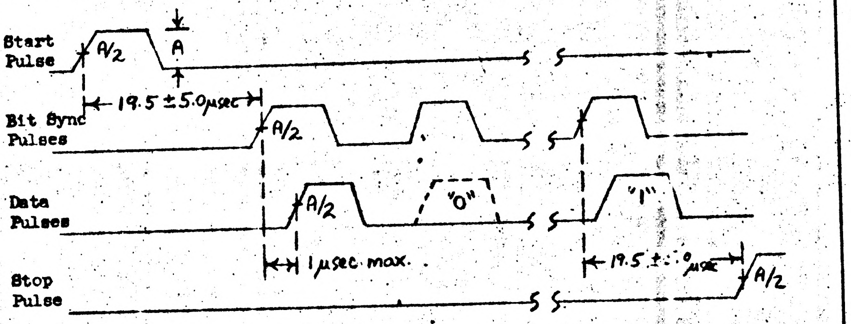
Range: > 100 msec.

Range Rate: > 100 msec.

Velocities: 80 msec.

SECTION III-3

Down Link Timing


Start
Pulse
A/2
A
19.5 ± 5.0 μsec
Bit Sync
Pulses
A/2
Data
Pulses
A/2
"0"
"1"
1 μsec max.
Stop
Pulse
19.5 ± 5.0 μsec
A/2

a. Start pulses: rate 50 pps.

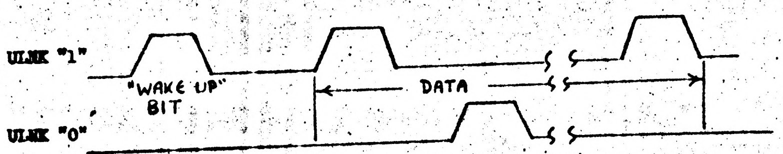
b. Bit sync pulses: Rate 51.2 Kpps. There will be 40 pulses between each start and stop pulse.

c. Data pulses: Frequency and width determined by bit sync pulses. A "1" is the presence of a pulse and a zero as the absence of a pulse with a bit sync pulse.

d. Stop pulses: Rate 50 pps.

SECTION III-4

Uplink Timing


ULNK "1"
"WAKE UP"
BIT
DATA
ULNK "0"

a. Bit rate of 0's and I's is 1.1 Kpps maximum.

b. 1 word is composed of 16 pulses; a "wake up" on the "I" line followed by 15 bits on the "I" or "0" lines.

c. Minimum time between words is 0.1 seconds.

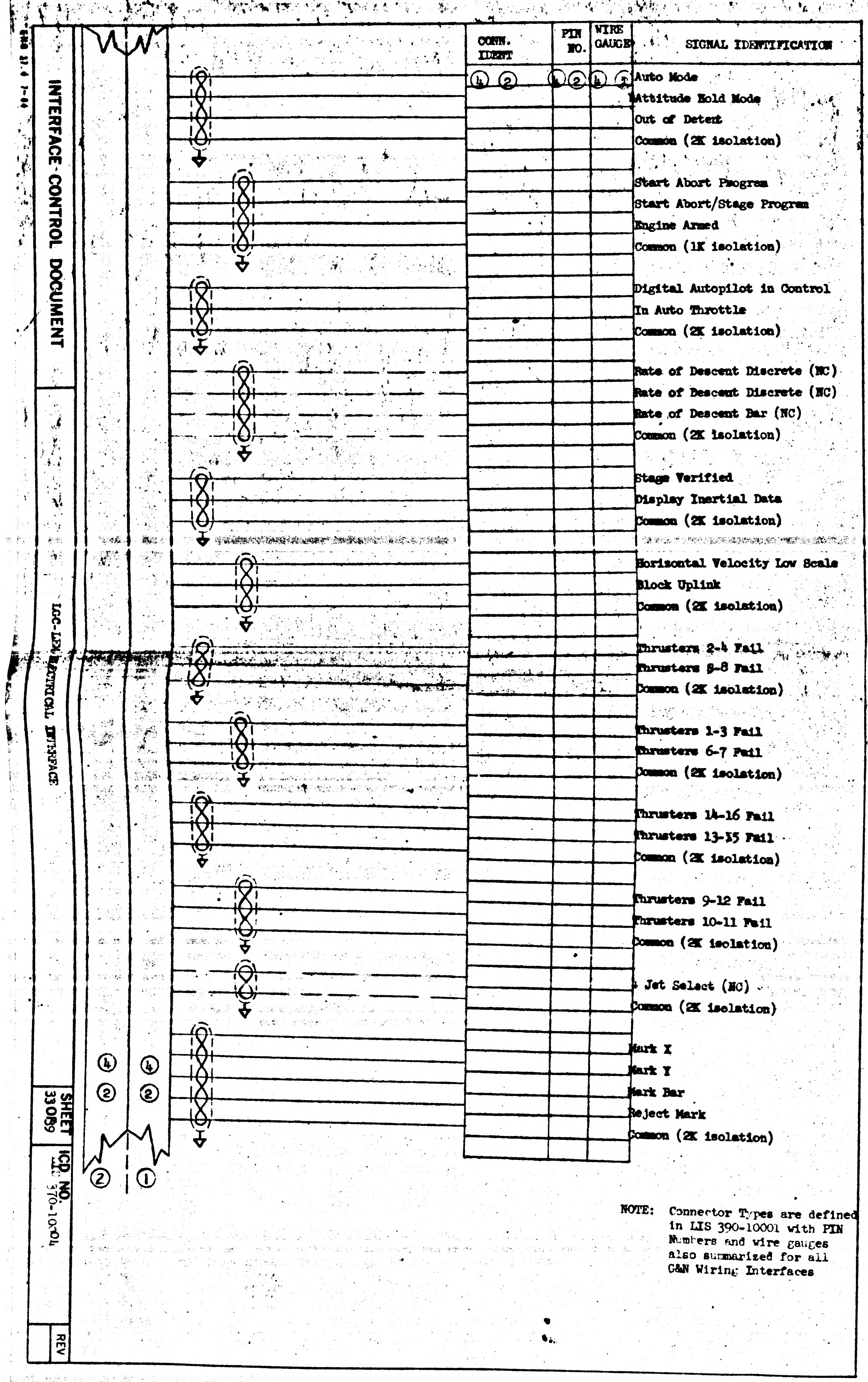
SECTION III-5

Altitude Output

1. The signal will be a 16 bit (15 data bits) whole number transfer. The number will be shifted out at a 3.2K pps rate on two lines.
2. The first pulse shall always be a "I" and will be on "wake up" pulse (not data).. The next 15 pulses will occur in the "I" or "O" lines depending as to whether the data in that bit position will be a "I" or a "O".
3. High order bits are shifted out first.
4. Quantization - 2.3450 feet equals least significant bit.
5. Data will be updated five times per second.

Altitude Rate Output

1. Same as (1) above.
2. Same as (2) above.
3. Same as (3) above.
4. Quantization ½ ft/sec equals least significant bit.
5. Same as (5) above.
6. Sign will be determined by a bias number; any digit greater than ④①② is positive.


INTERFACE CONTROL DOCUMENT
LGC-LEM ELECTRICAL INTERFACE
SHEET 33 OF 39
ICD NO. LIS 370-10004
REV
ENG 37.4 7-64
CONN. IDENT
PIN NO.
WIRE GAUGE
SIGNAL IDENTIFICATION
④ ②
④ ② ④ ②
Auto Mode
Attitude Hold Mode
Out of Detent
Common (2K isolation)
Start Abort Program
Start Abort/Stage Program
Engine Armed
Common (1K isolation)
Digital Autopilot in Control
In Auto Throttle
Common (2K isolation)
Rate of Descent Discrete (NC)
Rate of Descent Discrete (NC)
Rate of Descent Bar (NC)
Common (2K isolation)
Stage Verified
Display Inertial Data
Common (2K isolation)
Horizontal Velocity Low Scale
Block Uplink
Common (2K isolation)
Thrusters 2-4 Fail
Thrusters 5-8 Fail
Common (2K isolation)
Thrusters 1-3 Fail
Thrusters 6-7 Fail
Common (2K isolation)
Thrusters 14-16 Fail
Thrusters 13-15 Fail
Common (2K isolation)
Thrusters 9-12 Fail
Thrusters 10-11 Fail
Common (2K isolation)
4 Jet Select (NC)
Common (2K isolation)
Mark X
Mark Y
Mark Bar
Reject Mark
Common (2K isolation)
④ ②
④ ②
②
①

NOTE: Connector Types are defined in LIS 390-10001 with PIN Numbers and wire gauges also summarized for all G&N Wiring Interfaces

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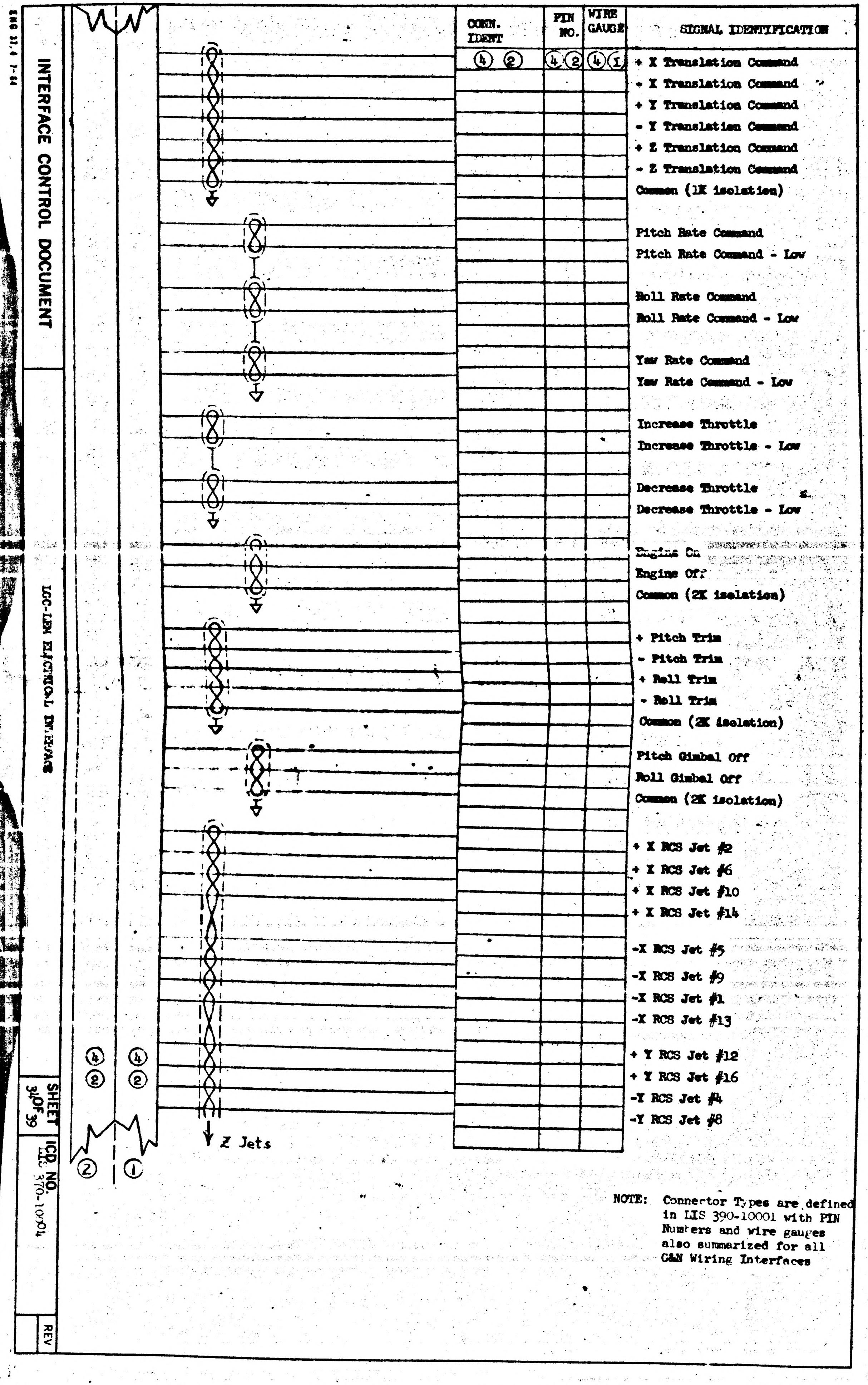
INTERFACE CONTROL DOCUMENT
LGC-LEM ELECTRICAL INTERFACE
SHEET 34 OF 39
ICD NO. LIS 370-10004
REV
ENG 37.4 7-64
CONN. IDENT
PIN NO.
WIRE GAUGE
SIGNAL IDENTIFICATION
④ ②
④ ② ④ ①
+ X Translation Command
- X Translation Command
+ Y Translation Command
- Y Translation Command
+ Z Translation Command
- Z Translation Command
Common (1K isolation)
Pitch Rate Command
Pitch Rate Command - Low
Roll Rate Command
Roll Rate Command - Low
Yaw Rate Command
Yaw Rate Command - Low
Increase Throttle
Increase Throttle - Low
Decrease Throttle
Decrease Throttle - Low
Engine On
Engine Off
Common (2K isolation)
+ Pitch Trim
- Pitch Trim
+ Roll Trim
- Roll Trim
Common (2K isolation)
Pitch Gimbal Off
Roll Gimbal Off
Common (2K isolation)
+ X RCS Jet #2
+ X RCS Jet #6
+ X RCS Jet #10
+ X RCS Jet #14
-X RCS Jet #5
-X RCS Jet #9
-X RCS Jet #1
-X RCS Jet #13
+ Y RCS Jet #12
+ Y RCS Jet #16
-Y RCS Jet #4
-Y RCS Jet #8
Z Jets
④ ②
④ ②
②
①

NOTE: Connector Types are defined in LIS 390-10001 with PIN Numbers and wire gauges also summarized for all G&N Wiring Interfaces

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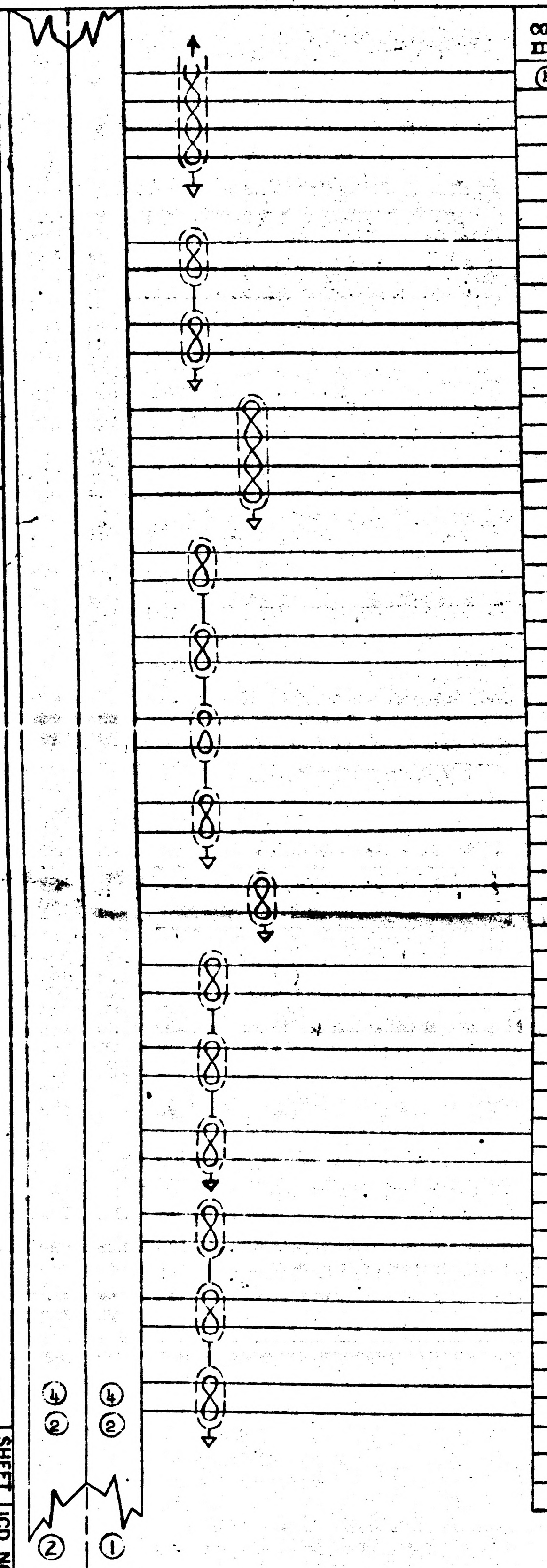

CONN. IDENT	PIN NO.	WIRE GAUGE	SIGNAL IDENTIFICATION
④ ②	④②	④ ①	+ Z RCS Jet #11
			+ Z RCS Jet #7
			- Z RCS Jet #3
			- Z RCS Jet #15
			RCS Jet Common (NC)
			RR in "1"
			RR in "1" - Low
			RR in "0"
			RR in "0" - Low
			RR Data Good
			RR Power On & Auto Mode
			RR Range Low Scale
			Common (1K isolation)
			RR Reset Strobe
			RR Reset Strobe - Low
			RR Range Gate Strobe
			RR Range Gate Strobe - Low
			RR Range Rate Gate Strobe
			RR Range Rate Gate Strobe -Low
			RR Counter Readout Command
			RR Counter Readout Command-Low
			Auto Angle Track Enable
			Auto Angle Track Enable-Return
			LR Reset Strobe
			LR Reset Strobe - Low
			LR Range Gate Strobe
			LR Range Gate Strobe - Low
			LR X_A Velocity Gate Strobe
			LR X_A Velocity Gate Strobe-Low
			LR Y_A Velocity Gate Strobe
			LR Y_A Velocity Gate Strobe-Low
			LR Z_A Velocity Gate Strobe
			LR Z_A Velocity Gate Strobe-Low
			LR Counter Readout Command
			LR Counter Readout Command-Low

NOTE: Connector Types are defined in LIS 390-10001 with PIN Numbers and wire gauges also summarized for all G&N Wiring Interfaces

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LGC-LEM ELECTRICAL INTERFACE

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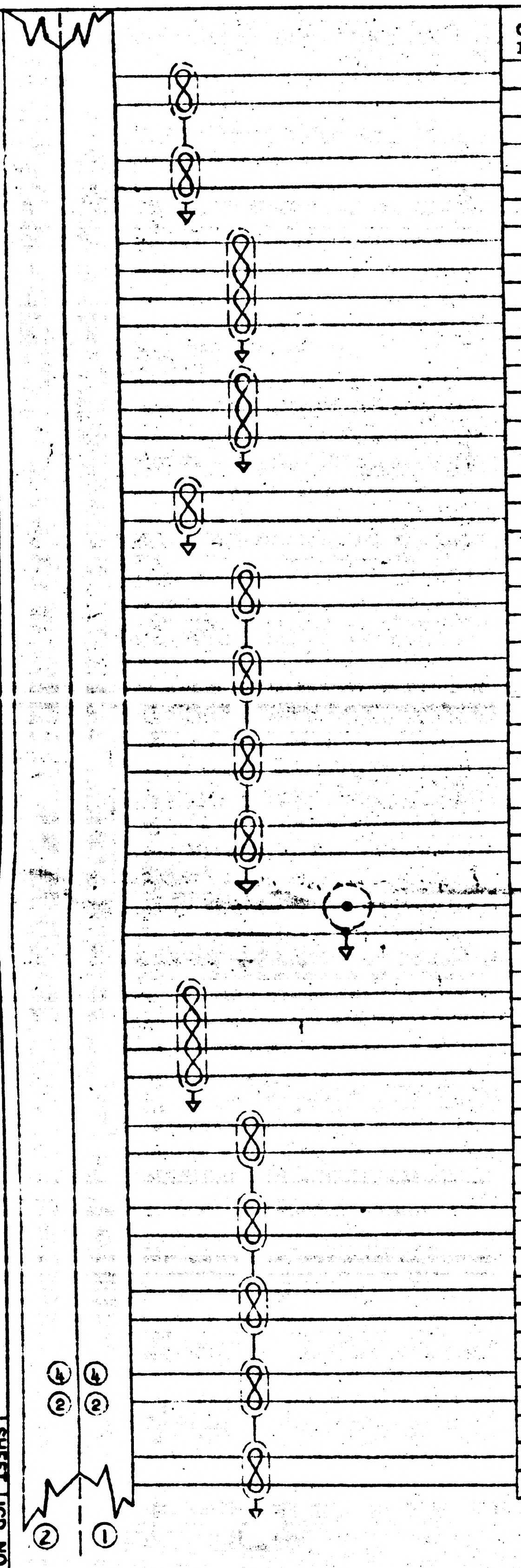

CONN. IDENT	PIN NO.	WIRE GAUGE	SIGNAL IDENTIFICATION
④ ②	④②	④①	LR in "1"
			LR in "1" - Low
			LR in "0"
			LR in "0" - Low
			LR Range Data Good
			LR Position #1 Indication
			LR Position #2 Indication
			Common (2K isolation)
			LR Velocity Data Good
			LR Range Low Scale Factor
			Common (2K isolation)
			LR Antenna Position Command
			Antenna Position Command-Return
			Start Pulse
			Start Pulse - Low
			Stop Pulse
			Stop Pulse - Low
			Bit Sync Pulse
			Bit Sync Pulse - Low
			Serial Digital Data
			Serial Digital Data - Low
			Sync Signal
			Sync Signal - Low
			LGC (Warning)
			PGNS (Caution)
			INERTL REF (Warning)
			C & W - Return
			Altitude "1"
			Altitude "1" - Low
			Altitude "0"
			Altitude "0" - Low
			Altitude Rate "1"
			Altitude Rate "1" - Low
			Altitude Rate "0"
			Altitude Rate "0" - Low
			Altitude Meter Sync
			Common (2K isolation)

NOTE: Connector Types are defined in LIS 390-10001 with PIN Numbers and wire gauges also summarized for all G&N Wiring Interfaces

INTERFACE CONTROL DOCUMENT

LGC-LEM ELECTRICAL INTERFACE

SHEET 36 OF 39

ICD NO. LIS 370-10004

REV

ENG 37.4 7-64

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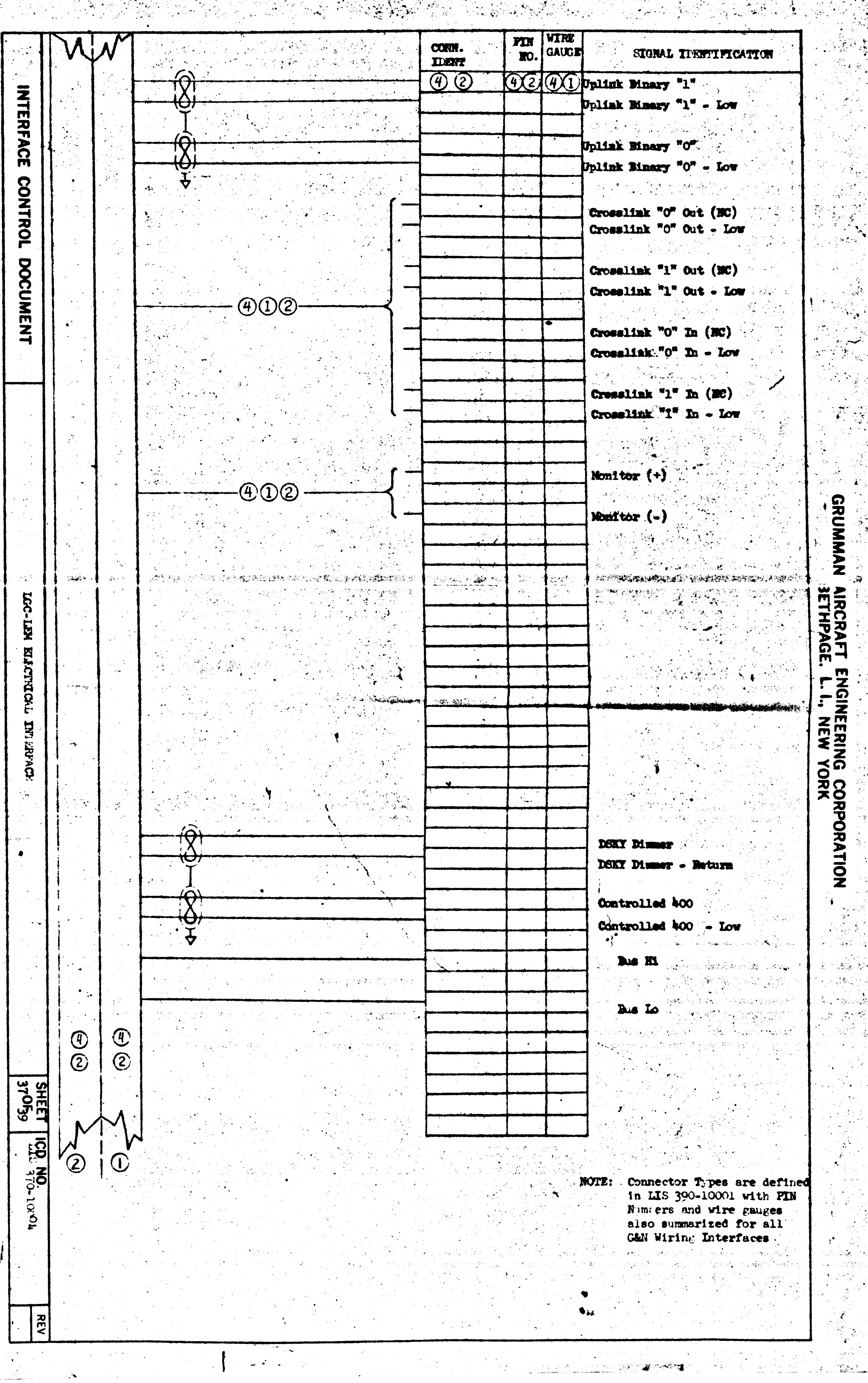
CONN. IDENT.
PIN NO.
WIRE GAUGE
SIGNAL IDENTIFICATION
④②
④②
④①
Uplink Binary "1"
Uplink Binary "1" - Low
Uplink Binary "0"
Uplink Binary "0" - Low
Crosslink "0" Out (NC)
Crosslink "0" Out - Low
Crosslink "1" Out (NC)
Crosslink "1" Out - Low
Crosslink "0" In (NC)
Crosslink "0" In - Low
Crosslink "1" In (NC)
Crosslink "1" In - Low
④①②
Monitor (+)
Monitor (-)
④①②
DSKY Dimmer
DSKY Dimmer - Return
Controlled 400
Controlled 400 - Low
Bus Hi
Bus Lo
④②
④②
②
①

NOTE: Connector Types are defined in LIS 390-10001 with PIN Numbers and wire gauges also summarized for all G&N Wiring Interfaces

INTERFACE CONTROL DOCUMENT

LGC-LEM ELECTRICAL INTERFACE

SHEET 37 OF 39

ICD NO. LIS 370-10004

REV

ENG 37.4 7-64

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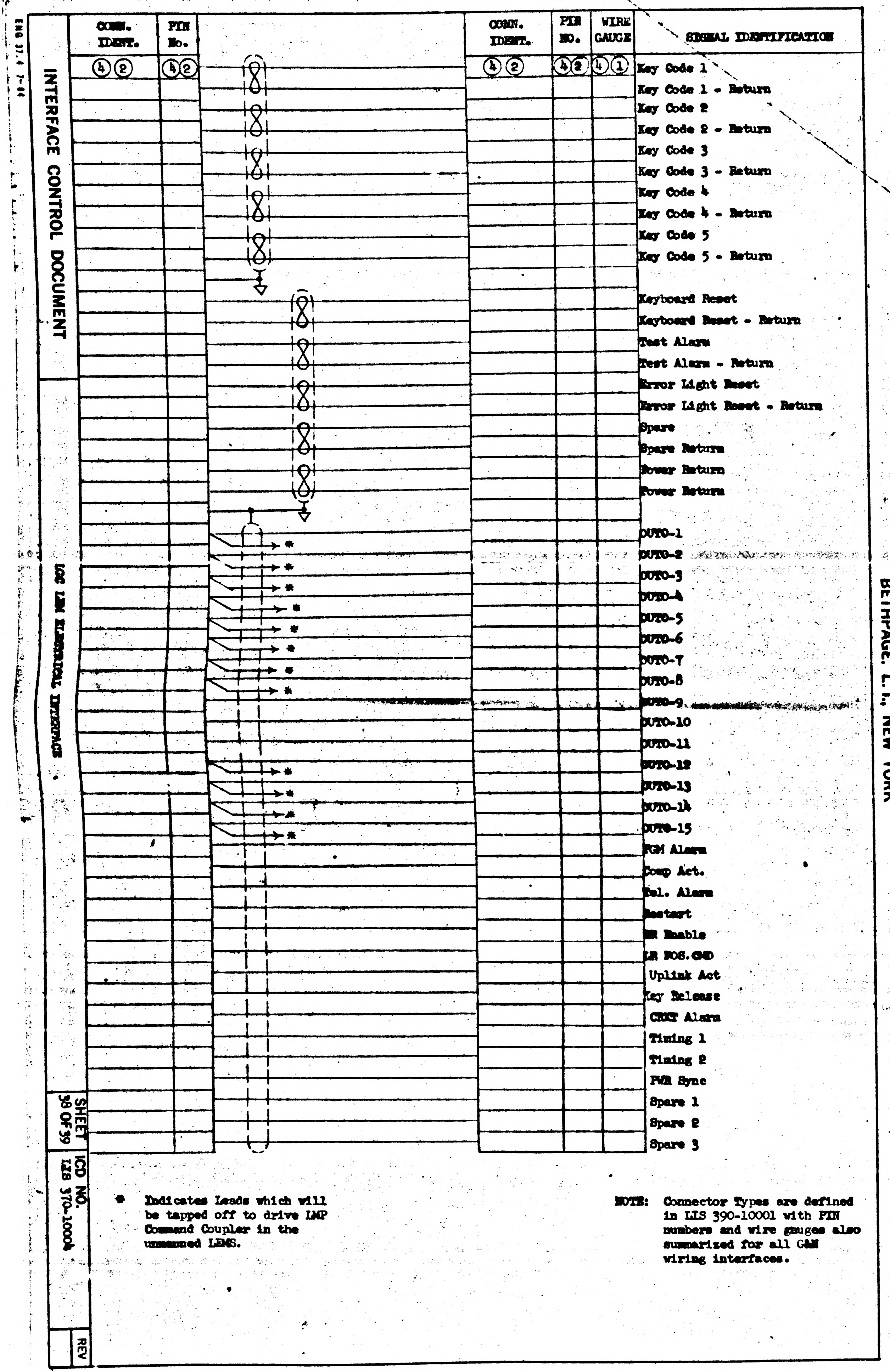

CONN. IDENT.
PIN NO.
CONN. IDENT.
PIN NO.
WIRE GAUGE
SIGNAL IDENTIFICATION
④②
④②
④②
④②
④①
Key Code 1
Key Code 1 - Return
Key Code 2
Key Code 2 - Return
Key Code 3
Key Code 3 - Return
Key Code 4
Key Code 4 - Return
Key Code 5
Key Code 5 - Return
Keyboard Reset
Keyboard Reset - Return
Test Alarm
Test Alarm - Return
Error Light Reset
Error Light Reset - Return
Spare
Spare Return
Power Return
Power Return
OUTO-1
OUTO-2
OUTO-3
OUTO-4
OUTO-5
OUTO-6
OUTO-7
OUTO-8
OUTO-9
OUTO-10
OUTO-11
OUTO-12
OUTO-13
OUTO-14
OUTO-15
PGM Alarm
Comp Act.
Tel. Alarm
Restart
RR Enable
LR POS.GND
Uplink Act
Key Release
CHKT Alarm
Timing 1
Timing 2
PWR Sync
Spare 1
Spare 2
Spare 3
*

* Indicates Leads which will be tapped off to drive LMP Command Coupler in the unmanned LEMS.

NOTE: Connector Types are defined in LIS 390-10001 with PIN numbers and wire gauges also summarized for all G&N wiring interfaces.

INTERFACE CONTROL DOCUMENT

LGC LEM ELECTRICAL INTERFACE

SHEET 38 OF 39

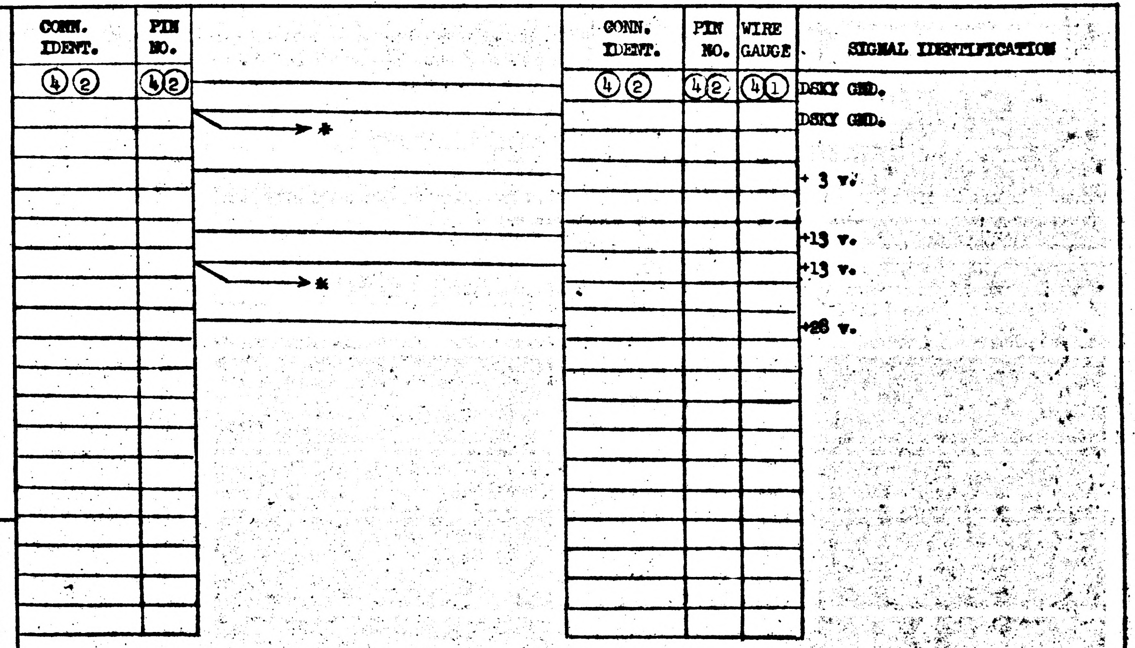
ICD NO. LIS 370-10004

REV

ENG 37.4 7-64

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

IDME 16647 FEB 18 1966


CONN. IDENT.
PIN NO.
④②
④②
*
*
CONN. IDENT.
PIN NO.
WIRE GAUGE
SIGNAL IDENTIFICATION
④②
④②
④①
DSKY GND.
DSKY GND.
+ 3 v.
+13 v.
+13 v.
+28 v.

* Indicates leads which will be tapped off to drive LMP Command Coupler in the unmanned LEMS.

NOTE: Connector types are defined in LIS 390-1000A with PIN NUMBERS and WIRE GAUGES also summarized for all GAC wiring interfaces.

INTERFACE CONTROL DOCUMENT

LGC - LEM ELECTRICAL INTERFACE

SHEET 39 OF 39

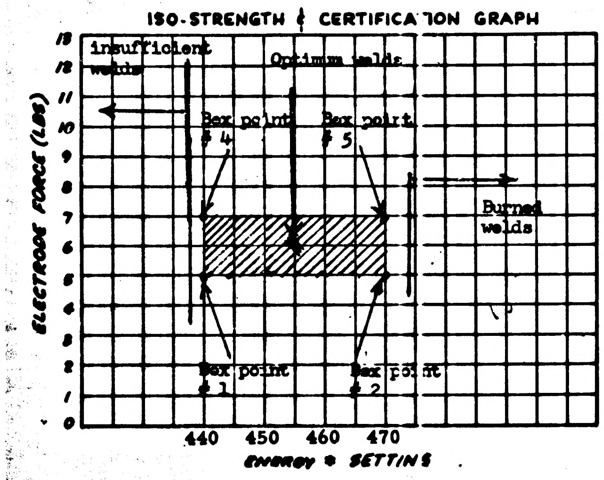
ICD NO. LIS 370-1000A

REV

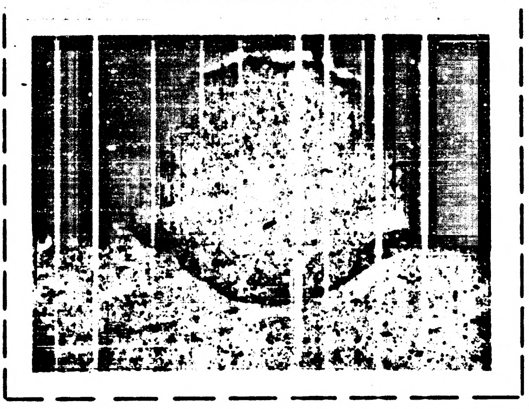
ENG 37.4 7-64

SAMPLE WELD DATA SHEET

ISO-STRENGTH & CERTIFICATION GRAPH



METALLURGICAL DATA



PHOTOMICROGRAPH
Optimum Point

INFORMATION:

1. MATERIAL:
UPPER .020 x .020 Ni.
LOWER .025 Dumet
2. WELDABILITY CODE NO. 22 B
3. TYPE OF HEAD J
4. ELECTRODE COMBINATION:
TOP TDS-0028
BOTTOM TDS-0038
5. ELECTRODE FORCE (LBS) 6
6. TAP SETTING:
AC 0 - 3.0 volts
DC ½ OR FULL ____

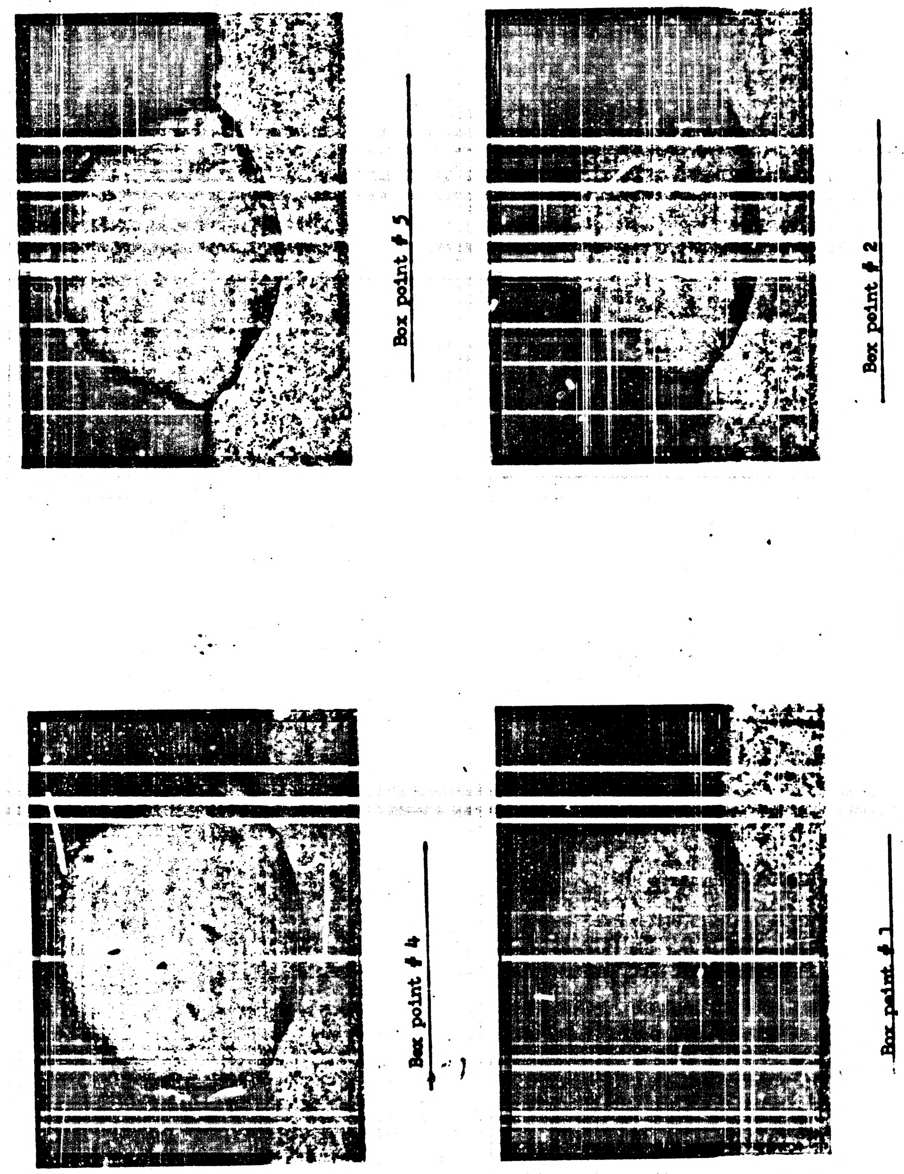
7. MACHINE SETTINGS:
CYCLES 1
MFD. ("S" OR "P") -
APPROX. % HEAT -
8. VERNIER READING PEAK 455
TOTAL ____
9. OPERATOR Pat Lee
10. CONTROL LIMITS:
UCL $\bar{X}$ -
LCL $\bar{X}$ 28.8
UCL R 6.5
LCL R -

MAGNIFICATION 100 x ETCH Carapella's
COMMENTS:
Good weld - shows fusion at interface and heat affected zone adjacent to it. Large deformation in both materials.

OK. Valey
SIGNATURE

Figure 2

* Weld power monitor readings



Box point # 5

Box point # 2

Box point # 4

Box point # 1

Figure 3

PG 1 OF 1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 PI (1-65)

R-30729

TDRR NO. 37149

TITLE OF DWG/DOC. MARGINAL VOLTAGE TEST	CONTRACTOR NO. R-1086	DOC. NO. DASH NO. JDC 04253	REVISION FROM A	TO B
	MIT ENGINEER E. HALL			
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/16/68	TYPE OF DOC 09		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

1. ADD REV "B" TO REV LTR COL

2. CHANGE IN STEP A-13. FROM "PRESS ON CH33-15 AND CH30-10." TO "PRESS ON CH30-15 AND CH33-10."

UP REV ALL PAGES OF JDC AND DATA SHEET FROM "A" TO "B"

REASON FOR CHANGES

DOCUMENT CORRECTION

DOC CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON

NEXT HIGHER ASSY: PS 2016032

REMARKS:

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY RFE. C. Coppola

DESIGN REVIEW APPROVAL MIT/IL
Eldon C Hall 12/19/68
W Stameris 19 Dec 68

MIT CCB APPROVAL 1/6/69
MG Murphy 21 Dec 68

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
TA Kurofsky 3 Jan 69
1/3/69

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

006

TDRR NO. 37149

REISSUE
12/3/68

PG 1 OF 1
TDRR NO. 37026

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

R1843

TITLE OF DWG/DOC. Procurement Specification for Long Eye Relief Eyepiece Assembly (SCT)	CONTRACTOR NO. K-1010 MIT ENGINEER E. THORUP	DOC. NO. DASH NO PS2012790	REVISION FROM - TO A
SYSTEM OR SUBSYSTEM G & N	DATE ORIGINATED 10-18-68	TYPE OF DOC. PS 02	

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 752

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☐ AC SPARK ☒ KOLLSMAN

DESCRIPTION OF CHANGES

Page 1 Paragraph 1 Revise:

From: This specification establishes the .... acceptance of the SCT Long Eye Relief Eyepiece Assembly, Part No. 2012790-000.

* To: This specification establishes the .... acceptance of the SCT Long Eye Relief Eyepiece Assembly, Part No. 2012790-000 and 2012790~~-011~~.
-011

REASON FOR CHANGES

Addition of locating ring on assembly for installation of high density filter.

DOC. CLASS A	OTHER DOCS. AFFECTED	EFFECTIVITY		
		HARDWARE		SPARES
		CUT-IN	CUT-OUT	
REV. CLASS II				

ORGANIZATION AFFECTED Kollsman	NEXT HIGHER ASSY	DISPOSITION OF PARTS ON HAND			
		DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
REMARKS	DOCUMENT NUMBER REPLACED	NO CHANGE			
		MODIFY			
	INTERFACE AFFECTED	SCRAP			

PREPARED BY R. Lawrence 10/24/68	DESIGN REVIEW APPROVAL MIT/IL W Stameris 30 Oct 68	MIT CCB APPROVAL MG Tinley 11/14/68
ENGINEERING APPROVAL MIT/IL E. Thorup 10/30/68	CONTRACTOR APPROVAL LDT Thomas L Herman 7 Nov 68	NASA APPROVAL NOT REQUIRED CCA497-0278

REISSUE DATE: 12/3/68 REASON:
* REISSUE TO CLARIFY. CORRECTION DID NOT Reproduce Correctly

CCB INITIAL
MIT-
CONTR-
NASA-

TDRR NO. 37026

888

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
TDRR NO. 37158

M

TITLE OF DWG/DOC. Specification for Procurement of Apollo II Inertial Reference Integrating Gyro	CONTRACTOR NO. A18391 MIT ENGINEER P. Kerrigan	DOC. NO. PS 2021500	REVISION FROM P TO R
SYSTEM OR SUBSYSTEM 25 IRIG	DATE ORIGINATED 11-12-68	TYPE OF DOC. Procurement Spec 02	

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ______

MASTER DOCUMENT LOCATION
☒ MIT/IL ☐ RAYTHEON
☐ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

Change Second Sentence of Para. 4.2.2.4.2.2

From: The ratio of the change in S.G. magnetic suspension current due to axial float motion from the quiescent positions to each pivot shall be no greater than 2.3 to 1.

To: The change in S.G. magnetic suspension current due to axial float motion from the quiescent position to each pivot shall be no greater than 30 ma and no less than ~~X~~ 7 ma.

REASON FOR CHANGES

This change permits consideration of the suspension capability of the SG and TG ducosyns individually, while maintaining limits of axial travel within the present requirements.

DOC. CLASS A
REV. CLASS 2

OTHER DOCS. AFFECTED: None

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
NA	NA	NA

ORGANIZATION AFFECTED: MIT/AC Electronics
NEXT HIGHER ASSY: 2021500
REMARKS:
DOCUMENT NUMBER REPLACED: NA
INTERFACE AFFECTED: NA

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

PREPARED BY D. R. Kilimann
D. R. Kilimann 11-8-68

DESIGN REVIEW APPROVAL MIT/IL 12/16/68

MIT CCB APPROVAL 12/27/68 17 Dec

ENGINEERING APPROVAL MIT/IL
P R Kerrigan 11-22-68

CONTRACTOR APPROVAL 12/16/68

NASA APPROVAL 1/8/69

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

009

TDRR NO. 37158

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
TDRR NO. 37165

TITLE OF DWG / DOC. G&N Spacecraft Equipment, Block II	CONTRACTOR NO. MIT ENGINEER	DOC. NO. 2015000	REVISION FROM CZ	REVISION TO DA
SYSTEM OR SUBSYSTEM Apollo G&N (High Density Filters)	DATE ORIGINATED 1-6-69	TYPE OF DOC. Drawing 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 752
CCA-497-597 R1

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. Add FIND No's. 32 and 33 as follows:

Effectivity Undefined	Subsystem	Qty	Equip. Code	FIND No.
2012816-000	SCT LER Eyepiece High Density Filter Assy.		65	33 } See Note 7
2012808-000	SCT STD Eyepiece High Density Filter Assy.		65	32 }

REASON FOR CHANGES

Add End Items Authorized per CCA 497-597 R1 (ECP 752)

DOC. CLASS A
REV. CLASS I

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
- See	Above -	

ORGANIZATION AFFECTED: AC Electronics
NEXT HIGHER ASSY: ND 1000000
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND N/A

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			-
SCRAP			

PREPARED BY: E. H. Ekwall
DESIGN REVIEW APPROVAL MIT/IL: N/A
MIT CCB APPROVAL: 1/7/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL:
NASA APPROVAL: 1/7/69

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

200

TDRR NO. 37165

PG 1 OF 1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

TDRR NO. 37170

TITLE OF DWG / DOC.: K-Start Tape Assembly
CONTRACTOR NO.:
MIT ENGINEER:
DOC. NO. / DASH NO.: See Below
REVISION FROM: - TO: -
SYSTEM OR SUBSYSTEM: Post Installation Testing
DATE ORIGINATED: 1-6-69
TYPE OF DOC.: DWG 10

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

EQUIP CODE 55

DWG NO.	TAPE NO.	TITLE	LISTING DATE
1026210	F10L004-K10515-00	Mated Systems C/O	12/16/68
1026211	F10L004-K10516-00	Staged Systems C/O	12/16/68
1026212	F10L004-K10517-00	Valve Sig. Profile	1/6/69
1026213	F10L004-K10518-00	LM ACA - LGC I/F	12/16/68
1026214	F10L004-K10525-00	Roll/Yaw Jets Drycycle	12/16/68
1026215	F10L004-K10530-00	LM SAMOD (CDU OPCK)	12/18/68
1026216	F10L004-K10531-00	LM G&N Operational	12/18/68
1026217	F10L004-K10532-00	RCS CWEA - 1	12/16/68
1026218	F10L004-K10533-00	RCS CWEA - 2	12/10/68
1026219	F10L004-K10534-00	RCS CWEA - 3	12/16/68
1026220	F10L004-K10535-00	LM FDAI TOT-ATT/ATT-ERR	12/6/68
1026221	F10L004-K10538-00	LGC Self Test	1/3/69
1026222	F10L004-K10539-00	RCS C&W I/F	12/16/68

REASON FOR CHANGES: Initial Release

SHIPPING PACKAGE
1. Two (ea.) tapes, 1 (ea.) card deck, 1 (ea.) listing
2. 1 (ea.) Certification and Verification Checklist
3. 1 (ea.) Memo describing Verification of K-start tapes
4. 1 (ea.) TDRR #

DOC. CLASS A
REV. CLASS N/A
OTHER DOCS. AFFECTED:

EFFECTIVITY
HARDWARE CUT-IN / CUT-OUT: N/A
SPARES:

ORGANIZATION AFFECTED: AC/KSC
NEXT HIGHER ASSY: 6014999
REMARKS: To be used with LUMINARY 69
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: V. Dahlmann
DESIGN REVIEW APPROVAL:
~~MIT~~ CCB APPROVAL: 1/6/69
ENGINEERING APPROVAL: R.T. Brandt
CONTRACTOR APPROVAL:
NASA APPROVAL: NOT REQUIRED CCA 9?-0078
REISSUE DATE: ______ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

TDRR NO. 37170

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
G TDRR NO. 37175

TITLE OF DWG/DOC. Cabinet Assembly, Electrical Equipment, Optics Inertial Analyzer Assembly	CONTRACTOR NO. A-18451	DOC. NO. 2900032	REVISION FROM R	TO S
	MIT ENGINEER J. Watson			
SYSTEM OR SUBSYSTEM Apollo GSE	DATE ORIGINATED 1-8-69	TYPE OF DOC. Drawing 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

Sheet 1, Zone C-5

Item 66 in the -031 column, change From: "X" To: "_".

REASON FOR CHANGES

Running List improperly called out for -031 configuration.

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED

EFFECTIVITY N/A

HARDWARE		SPARES
CUT-IN	CUT-OUT	

ORGANIZATION AFFECTED
AC Electronics

NEXT HIGHER ASSY
2900023

REMARKS:

DOCUMENT NUMBER REPLACED

INTERFACE AFFECTED

DISPOSITION OF PARTS ON HAND N/A

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY
H. Williams 12-13-68

DESIGN REVIEW APPROVAL MIT/IL
N/A

~~MIT~~ CCB APPROVAL
1/9/69

ENGINEERING APPROVAL ~~MIT/IL~~

CONTRACTOR APPROVAL

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

G TDRR NO. 37175

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
TDRR NO. 37176

TITLE OF DWG/DOC. INSTALLATION OF THE PIPA ELECTRONICS ASSEMBLY TO THE PTA/PEA MOUNTING FIXTURE ASSEMBLY ON THE ROTARY TABLE	CONTRACTOR NO. A 18452 MIT ENGINEER	DOC. NO. DASH NO. JDC 14014	REVISION FROM B TO C
SYSTEM OR SUBSYSTEM INERTIAL	DATE ORIGINATED 1-8-69	TYPE OF DOC. JDC 09	

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

Add the following IMPORTANT note:

> IMPORTANT: Refer to JDC 18100 for lubrication instructions prior to engaging any screw or bolt into header helicoil inserts, and for helicoil insert cleaning instructions after all testing has been completed or prior to spacecraft installation.

REASON FOR CHANGES

To incorporate reference to JDC as a result of release of JDC 18100 (Lubrication and Cleaning of Component Header Helicoil Inserts and Engaging Hardware).

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A	N/A	

ORGANIZATION AFFECTED: AC Electronics

NEXT HIGHER ASSY: ND 1021043 and ATP 2015497

REMARKS: No retest required

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: None

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

PREPARED BY R.E. Marks P. M. Headley	DESIGN REVIEW APPROVAL MIT/IL N/A	MIT CCB APPROVAL 1/9/69
ENGINEERING APPROVAL MIT/IL	CONTRACTOR APPROVAL	NASA APPROVAL RAH/Boeing 1-6-9

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

600

TDRR NO. 37176

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
TDRR NO. 37177

TITLE OF DWG / DOC. SXT TRUNNION ACCURACY TEST	**CONTRACTOR NO.** A 18453 **MIT ENGINEER**	**DOC. NO.** JDC 20106	**REVISION** **FROM** E	**TO** F
SYSTEM OR SUBSYSTEM Optical Subsystem	**DATE ORIGINATED** 1-8-69	**TYPE OF DOC.** JDC 09		

☐ INITIAL RELEASE	☒ TDRR ONLY	**MASTER DOCUMENT LOCATION**
☒ REVISION	☐ TDRR & DOCUMENT	☐ MIT/IL ☐ RAYTHEON
☐ NON-INTERCHANGEABLE REPLACEMENT	☐ ECP NO. ________	☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

Page 2. Insert the following NOTE after step 15.

NOTE: With the Optics in the MANUAL mode and the TRUNNION SLEW CONTROL in the OFF position the Optics Trunnion may drive in a positive direction due to the action of the trunnion spring.

REASON FOR CHANGES

To clarify Optics operation.

DOC. CLASS A ~~II~~

REV CLASS II ~~II~~

OTHER DOCS. AFFECTED

NONE

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A		

ORGANIZATION AFFECTED
AC Electronics

NEXT HIGHER ASSY
ATP 2015500, ND 1021043

REMARKS:
No retest required.

DOCUMENT NUMBER REPLACED
N/A

INTERFACE AFFECTED
None

DISPOSITION OF PARTS ON HAND N/A

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY W. Thomas	**DESIGN REVIEW APPROVAL MIT/IL** N/A	**~~MIT~~ CCB APPROVAL** 1/9/69
ENGINEERING APPROVAL ~~MIT/IL~~	**CONTRACTOR APPROVAL**	**NASA APPROVAL** RJH/Boeing 1-6-9

REISSUE DATE:________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TDRR NO. 37177

009

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 1
TDRR NO. 37178

TITLE OF DWG / DOC. K-Start Tape Assembly SAMOD INHINT GUARD	**CONTRACTOR NO.**	**DOC. NO.** 1026193	**REVISION FROM** -	**REVISION TO** A
	MIT ENGINEER			
SYSTEM OR SUBSYSTEM G&N Post Installation Testing	**DATE ORIGINATED**	**TYPE OF DOC.** DWG 10		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

Add Tape Number G03L005-K10540-01

SHIPPING PACKAGE:

1. Two tapes, 1 card deck, 1 listing.
2. Certification and Verification Checklist
3. APM 18914
4. TDRR # 37178

REASON FOR CHANGES

Additional time delay was added to Section 0101 (Card 270) to allow completion of V36 function.

DOC. CLASS A
REV. CLASS I

OTHER DOCS. AFFECTED

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
LM-5	-	

ORGANIZATION AFFECTED
AC/GAEC

NEXT HIGHER ASSY
6014999

REMARKS:
For use with
AURORA 88

DOCUMENT NUMBER REPLACED
N/A

INTERFACE AFFECTED
N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY
V. Dahlmann

DESIGN REVIEW APPROVAL

~~MIT~~ CCB APPROVAL 1/10/69

ENGINEERING APPROVAL

CONTRACTOR APPROVAL

NASA APPROVAL

REISSUE DATE: ______ **REASON:**

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37178

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 PI (1-68)

R-30689

PG 1 OF 1
TDRR NO. 37179

TITLE OF DWG/DOC: SEE BELOW
SYSTEM OR SUBSYSTEM: AGC BL II
CONTRACTOR NO.: R-1070
MIT ENGINEER: E HALL
DATE ORIGINATED: 12/11/68
DOC NO. / DASH NO.: SEEBELOW (2 DWG)
TYPE OF DOC.: 01
REVISION FROM: # TO: —

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIPCODE 05

DESCRIPTION OF CHANGES

ITEM NO.	DOC. NO.	DOC. TITLE	NHA
1	2005976	SIGNAL FLOW DIAGRAM AGC DSKY	2003985
2.	2005977	SIGNAL FLOW DIAGRAM AGC DSKY	2003994 2003950

REASON FOR CHANGES: INITIAL RELEASE

DOC. CLASS A
REV. CLASS —

OTHER DOCS AFFECTED: REF: PC/SN: R1067; 2003994: R1068: 2003950: R1069: 3003985:

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: SEE LIST
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: McMirow
REF. E. BOWEN
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68; W Stameris 20 Dec 68
MIT CCB APPROVAL: M G Minder 12-24-68; 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: TA Kosofsky; D. Klum 1/10/69; 12/20/68
NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ______ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

018

TDRR NO. 37179

PG 1 OF 1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P1 (1-65)

R-30689

TDRR NO. 37180

TITLE OF DWG/DOC. SEE BELOW	CONTRACTOR NO. R-1075 MIT ENGINEER E. HALL	DOC. NO. DASH NO. SEE BELOW	REVISION FROM # TO —
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/11/68	TYPE OF DOC. SEE BELOW	

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ ECP NO. 739
CCA594-R1

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

ITEM NO.	DOC. TYPE	DOC. NO.	DOC TITE
1.	01	8104252	RETROFIT KIT LIST FOR ECP 739 INDICATOR STATUS/CAUTION
2,	12	0104136	RIB DSKY STATUS/CAUTION AUTHORIZED BY ECP 739

REASON FOR CHANGES

INITIAL RELEASE

DOC. CLASS A

REV. CLASS —

OTHER DOCS. AFFECTED

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	N/A

ORGANIZATION AFFECTED: MIT / RAYTHEON

NEXT HIGHER ASSY: 8104001

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

REMARKS:

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	N/A		N/A
MODIFY			
SCRAP			

PREPARED BY M. MIROW
REF E. BOWEN

DESIGN REVIEW APPROVAL MIT/IL
E. Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL
M G Mutley
12-24-68
1/10/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
Z A Kruolosky 3 Jan 69
1/3/69
12/20/68

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT -
CONTR -
NASA -

TP8913

TDRR NO. 37180

PG 1 OF 1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 83-4026 P1 (1-68)

R-30689

TDRR NO. 37182

TITLE OF DWG/DOC.: SEE BELOW

CONTRACTOR NO.: R-1083

MIT ENGINEER: E. HALL

DOC. NO. DASH NO.: PS2016040

REVISION FROM: # TO: —

SYSTEM OR SUBSYSTEM: AGC BL II

DATE ORIGINATED: 12/14/68

TYPE OF DOC.: 02

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIA CODE: 05

DESCRIPTION OF CHANGES

INITIAL RELEASE

PROCUREMENT SPECIFICATION, PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS INDICATOR STATUS/CAUTION SCD NO. 1005025.

REASON FOR CHANGES

INITIAL RELEASE

DOC CLASS A

REV. CLASS —

OTHER DOCS. AFFECTED: REF PC/SN R 1077 1005025

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON

NEXT HIGHER ASSY: 1005025

REMARKS:

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: C W Mirow
REF. W. PLATT

ENGINEERING APPROVAL MIT/IL:

DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL: 12-24-68 1/10/69

CONTRACTOR APPROVAL: 12/20/68 1/10/69

NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37182

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P1 (1-65)

PG 1 OF 1
TDRR NO. 37193

TITLE OF DWG/DOC: G+N MASTER RKL COMPUTER SUBSYSTEM
CONTRACTOR NO.: R-1076
MIT ENGINEER: E. HALL
DOC. NO. DASH NO.: 8104001
REVISION FROM: AW TO: AY
SYSTEM OR SUBSYSTEM: AGC BL II
DATE ORIGINATED: 12/11/68
TYPE OF DOC: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739 CCA-497-594R1

MASTER DOCUMENT LOCATION
☐ MIT/IL
☐ RAYTHEON
☒ AC SPARK
☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES
SHEETS 1,2,&3 OF 4 NO CHANGE UPREV FROM "AW" TO "AY"

SHEET 4 OF 4
ADD ITEM 50.0 AS FOLLOWS " DESC; DSKY STATUS/CAUTION: END/ITEM; AGC DSKY ASSY: AGC S/N; ; RIB. NO; 0104136: ECP NO. 739
P/N MOD; 2003994-041; 2003994-051, 2003950-051, 2003985-041: RFA NO: 8104252: NEW PART NO: 2003994-061, 2003994-071; 2003950-071, 2003985-091:
LM5-LM15, 5 LM SIM (MSC), 2 (MIT/IL)
GAEC FCI, 2 SPARES

REASON FOR CHANGES
TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC. CLASS: A
REV. CLASS: I
OTHER DOCS. AFFECTED: REF: PC/SN R1067; 2003994: R1068: 2003950: R1069 2003985
EFFECTIVITY — HARDWARE — CUT-IN / CUT-OUT: SEE ABOVE
EFFECTIVITY — SPARES:
ORGANIZATION AFFECTED: AC/MIT/RAY
NEXT HIGHER ASSY: N/A
DOCUMENT NUMBER REPLACED: NA
INTERFACE AFFECTED: N/A
REMARKS:

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: M. MIROW X
REF E. BOWEN
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68; 20 Dec 1968
MIT CCB APPROVAL: 12-24-68; 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: 10 Jan 69; 12/20/68; 1/10/69
NASA APPROVAL:
REISSUE DATE: ________ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

014

TDRR NO. 37193

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 83-4026 PI (1-65)

R-30689

PG 1 OF 1
TDRR NO. 37194

TITLE OF DWG/DOC. SEE BELOW	CONTRACTOR NO. R-1084	DOC. NO. DASH NO. SEE BELOW	REVISION FROM #	REVISION TO —
	MIT ENGINEER E. HALL			
SYSTEM OR SUBSYSTEM AGC BLII	DATE ORIGINATED 12/14/68	TYPE OF DOC 02		

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

DOC NO.	DOC. TITLE.
PS2016037	PROCUREMENT SPECIFICATION. PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS, DISPLAY AND KEYBOARD ASSEMBLY. DRAWING NO 2003950.
PS2016038	PROCUREMENT SPECIFICATION. PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS. DISPLAY AND KEYBOARD ASSEMBLY. DRAWING NO. 2003994.

REASON FOR CHANGES

INITIAL RELEASE

DOC. CLASS A
REV. CLASS —

OTHER DOCS. AFFECTED
REF. PC/SN R1067 2003994: R1068 2003950

EFFECTIVITY HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON

NEXT HIGHER ASSY: 2003994: 2003950

REMARKS:

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY
REF. W. PLATT.

ENGINEERING APPROVAL MIT/IL

DESIGN REVIEW APPROVAL MIT/IL
Eldon C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL
12-24-68
1/10/69

CONTRACTOR APPROVAL
10 Jan 69
12/20/68
1/10/69

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37194

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION E-30689
FORM 53-4026 P1 (1-68)

PG 1 OF 1
TDRR NO. 37195

TITLE OF DWG / DOC.: SEE BELOW
CONTRACTOR NO.: R-1085
MIT ENGINEER: E. HALL
DOC. NO. / DASH NO.: PS2016041
REVISION FROM: # TO:
SYSTEM OR SUBSYSTEM: AGC BLK II
DATE ORIGINATED: 12/18/68
TYPE OF DOC: 02

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☐ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

PROCUREMENT SPECIFICATION, PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS, DISPLAY AND KEYBOARD ASSEMBLY DRAWING NO. 2003994

REASON FOR CHANGES

INITIAL RELEASE

DOC. CLASS: A
REV. CLASS: —

OTHER DOCS. AFFECTED: REF PC/SN R1167 2003994

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003994
REMARKS:
DOCUMENT NUMBER, REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: REE. W. PLATT.
ENGINEERING APPROVAL MIT/IL:
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
WStameris 20 Dec 68
CONTRACTOR APPROVAL: TAKaughy 10Jan69 1/10/69 12/20/68
MIT CCB APPROVAL: 12-24-68 1/10/69
NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37195

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION E-30689
FORM B3-4026 PI (1-68)

PG 1 OF 1
TDRR NO. 37196

TITLE OF DWG/DOC: SEE BELOW
CONTRACTOR NO.: R-1082
MIT ENGINEER: E. HALL
DOC. NO. DASH NO.: PS2016039
REVISION FROM: # TO: —
SYSTEM OR SUBSYSTEM: AGC Bl II
DATE ORIGINATED: 12/14/68
TYPE OF DOC.: 02

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

INITIAL RELEASE

PROCUREMENT SPECIFICATION, PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS. DISPLAY AND KEYBOARD ASSEMBLY DRAWING NO. 2003985-091

REASON FOR CHANGES

INITIAL RELEASE

DOC. CLASS A
REV. CLASS —

OTHER DOCS. AFFECTED: REF DC/SN R1069 2003985

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003985
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: McMiriew
REF. W. PLATT.
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
W Stameris 20 Dec 1968
MIT CCB APPROVAL: M G Mundy 12 24 68 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: TA Kuofsky 10 Jan 69 E W Platt 12/20/68
NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ________ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

013

TDRR NO 37196

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30728 **TDRR NO.** 37166
FORM 83-4026 P1 (1-68)

TITLE OF DWG/DOC.: COVER FRONT AGC DSKY
CONTRACTOR NO.: R-1178
MIT ENGINEER: E. HALL
DOC. NO. DASH NO.: 2004739
REVISION FROM: C TO: D
SYSTEM OR SUBSYSTEM: AGC DSKY
DATE ORIGINATED: 12/16/68
TYPE OF DOC.: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

FOR CHANGES SEE PAGE 2 OF THIS TDRR
(PAGE 2 IS A MARKED SEPIA)

REASON FOR CHANGES

TO ELIMINATE TOLERANCE CONDITION AND DRAWING CLARIFICATION

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003994
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY Mirow
REF. D. ROSEN
DESIGN REVIEW APPROVAL MIT/IL: Ellen C Hall 12/19/68
W Stameris 19 DEC 68
MIT CCB APPROVAL: 1/9/69
12-24-68
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: 1-9-68
12/19/68
NASA APPROVAL: NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

002

TP8913

TDRR NO. 37166

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

REISSUE
1-10-69

PG 1 OF 2
TDRR NO. 36992

TITLE OF DWG/DOC.: MULTIPLE RELEASE
CONTRACTOR NO.: M00430
DOC. NO. / DASH NO.: SEE BELOW
REVISION FROM: / TO:
MIT ENGINEER: W. STAMERIS
SYSTEM OR SUBSYSTEM: ICD
DATE ORIGINATED: 5 NOV 1968
TYPE OF DOC.: ICD IRN 07

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☒ NR ☒ GAEC
☒ MIT/IL ☐ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE

DESCRIPTION OF CHANGES INITIAL RELEASE OF THE FOLLOWING DOCUMENTS

76 1. ICD LID-340-10008 REV A "AOT" FIELD OF VIEW (1SHEET ROLL SIZE)
76 2. ICD LIS-410-10002 REV A "INERTIAL COMPONENTS TEMPERATURE CONTROL SYSTEM INTERFACE (13 SHEETS)
76 3. ICD LIS-300-10002 REV A "ABORT GUIDANCE SECTION ELECTRICA INTERFACE WITH PRIMARY GUIDANCE & NAVIGATION SUBSYSTEM (16 SHEETS)

Equip Code 75 & 76

REASON FOR CHANGES

TO UPDATE DOCUMENTS

DOC. CLASS A
REV. CLASS

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY N/A

HARDWARE		SPARES
CUT-IN	CUT-OUT	

ORGANIZATION AFFECTED: MIT GAEC NR
NEXT HIGHER ASSY: N/A
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: W. STAMERIS
DESIGN REVIEW APPROVAL MIT/IL: W. Stameris 11-5-68
MIT CCB APPROVAL: 11-5-68
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: N/A
NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: 1-10-69 REASON:
*CORRECT PG. 2 ITEM 9 IRN NUMBER FROM: 6293
TO: 6292

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

010

TDRR NO. 36992

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 2
TDRR NO. 37171

TITLE OF DWG/DOC. Spacecraft Installation List - Block II
CONTRACTOR NO.
MIT ENGINEER
DOC. NO. 2014999
REVISION FROM BT TO BU
SYSTEM OR SUBSYSTEM Apollo G&N
DATE ORIGINATED 1-6-69
TYPE OF DOC. Drwg. 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. In line titled "G&N Systems" (on Page 3 of 3) change G&N system numbers as follows:
   "221" to "220" for configuration dash No. - 201.
   "220" to "221" for configuration dash No. - 211.

2. In column titled "Outstanding ECP's Planned for Retrofit"

   Add: ECP 754 for G&N Systems 205(-051), 206(-061), and 209(-091) thru 222(-221).
   Add: ECP 752 for G&N Systems 205(-051), 206(-061), 213(-131), and 216(-161) thru 222(-221).
   Delete: ECP 752 from G&N System 209(-091).
   Delete: ECP 688 from G&N 204(-041) and 208(-081).

3. FIND No. 105 - Change P/N "2012790-000" to "2012790-011" for G&N Systems 209(-091), 210(-101), 211(-111), 212(-121), 214(-141), and 215(-151).

REASON FOR CHANGES

1. To correct erroneous entry in accomplishment of revision per TDRR 37116.
2. Thru 11. To update drawing for latest ECP and system configuration information.

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED N/A

EFFECTIVITY N/A

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES

ORGANIZATION AFFECTED AC ELECTRONICS
NEXT HIGHER ASSY ND 1000000
REMARKS:
DOCUMENT NUMBER REPLACED N/A
INTERFACE AFFECTED N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY E. H. Ekwall
DESIGN REVIEW APPROVAL MIT/IL N/A
MIT CCB APPROVAL 1/7/69
ENGINEERING APPROVAL MIT/IL
CONTRACTOR APPROVAL
NASA APPROVAL NOT REQUIRED CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

TDRR NO. 37171

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 2
TDRR NO. 37172

TITLE OF DWG/DOC. Spacecraft Installation List - LEM	**CONTRACTOR NO.** **MIT ENGINEER**	**DOC. NO.** 6014999	**REVISION FROM** BC	**TO** BD
SYSTEM OR SUBSYSTEM APOLLO G&N	**DATE ORIGINATED** 1-8-69	**TYPE OF DOC.** DRWG 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. In column titled, "Outstanding ECP's Planned for Retrofit"
   Delete ECP 757 from G&N System 606(-061) and 610(-101)
2. FIND No. 27 - Change P/N "6007200-071" to "6007200-081" for
   G&N Systems 606(-061), 607(-071), and 610(-101)
3. FIND No. 10 - Change P/N "2021110-021" to 2021110-031" for G&N System 605(-051).
4. FIND No. 4 - Change P/N "2021110-021" to 2021110-011" for G&N System 606(-061).

REASON FOR CHANGES

Update drawing for latest ECP and system configuration information.

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED
N/A

EFFECTIVITY N/A

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES

ORGANIZATION AFFECTED
AC Electronics

NEXT HIGHER ASSY
ND 1000000

REMARKS:

DOCUMENT NUMBER REPLACED
N/A

INTERFACE AFFECTED
N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY
E. H. Ekwall

DESIGN REVIEW APPROVAL MIT/IL
N/A

MIT CCB APPROVAL
1/8/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ **REASON:**

CCB INITIAL
MIT-
CONTR-
NASA-

008

TP8913

TDRR NO. 37172

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689 **TDRR NO.** 37181
FORM 83-4026 P1 (1-68)

TITLE OF DWG / DOC: P.S. DISPLAY AND KEYBOARD ASSEMBLY DWG NO. 2003994

CONTRACTOR NO.: R-1080

MIT ENGINEER: E. HALL

DOC. NO. DASH NO.: PS 2003994

REVISION FROM: J TO: K

SYSTEM OR SUBSYSTEM: AGC BL II

DATE ORIGINATED: 12/14/68

TYPE OF DOC.: 02

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ____

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

1. ADD REV "K" TO REV LTR COL

2. DELETE FROM TABLE 3-2 AS FOLLOWS

LOGIC INPUT	J9 INPUT PIN	INDICATOR ILLUMINATED	INDICATOR COLOR (REF. ONLY)	CONTACT CLOSURE BETWEEN PINS OF J9
1	66			33 AND 56
0	66			16 AND 56

REASON FOR CHANGES

DOCUMENT CORRECTIONS

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED: REF PC/SN R1067 2003994

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT / RAYTHEON

NEXT HIGHER ASSY: 2003994

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

REMARKS:

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

PREPARED BY: M Chirow
REF. W. PLATT

DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
WStameris 20 Dec 68

MIT CCB APPROVAL: 12 24 68 1/10/69

ENGINEERING APPROVAL MIT/IL:

CONTRACTOR APPROVAL: TA Drofting 10 Jan 69 Platt 12/20/68 1/10/69 1-10-69

NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

013

TDRR NO. 37181

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P1 (1-68)

PG 1 OF 2
TDRR NO. 37184

TITLE OF DWG/DOC.: INDICATOR STATUS/CAUTION SCD
CONTRACTOR NO.: R-1097
MIT ENGINEER: E. HALL
DOC. NO.: 1005025
DASH NO.:
REVISION FROM: —
REVISION TO: A
SYSTEM OR SUBSYSTEM: AGC BL II
DATE ORIGINATED: 12/13/68
TYPE OF DOC.: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL
☒ AC SPARK
☐ RAYTHEON
☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

SHEET 1 OF 3

NOTE APPLICATION CHART

1. CHANGE APPLICABLE NOTES FROM "7" TO "8"

SHEET 2 OF 3

2. ADD NOTE 8 AS FOLLOWS "SPARE MODULES ONLY: ALL SPARE MODULES MUST, IN ADDITION TO MEETING THE REQUIREMENTS OF THIS SPECIFICATION CONTROL DRAWING, BE TESTED TO AND PASS THE REQUIREMENTS OF PS 2016040 PRIOR TO SALE

REASON FOR CHANGES

TO ADD SPARES TESTING REQUIREMENT CAPABILITY

DOC. CLASS: A
REV. CLASS: II
OTHER DOCS. AFFECTED: REF. PC/SN R1067; 2003994; K1068, 2005750; [illegible]; 2003985

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/AC/RAY
NEXT HIGHER ASSY: 2003994
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A
REMARKS:

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: W. Wirow X
REF E. BOWEN
ENGINEERING APPROVAL MIT/IL:
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
W Stameris 20 Dec 68
CONTRACTOR APPROVAL: TA Kingsley 10 Jan 69
E A P 1-10-69
1/10/69
E C Hall 12/20/68
MIT CCB APPROVAL: [illegible] 12-24-68
1/10/69
NASA APPROVAL: NOT REQUIRED CCA497-0278
REISSUE DATE: ________ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

013

TDRR NO. 37184

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689 **TDRR NO.** 37186
FORM 83-4026 PI (1-68)

TITLE OF DWG/DOC.: SIGNAL FLOW DIAGRAM AGC DSKY
CONTRACTOR NO.: R-1078
MIT ENGINEER: E. HALL
DOC. NO. DASH NO.: 2005950
REVISION FROM: C TO: D
SYSTEM OR SUBSYSTEM: AGC BL II
DATE ORIGINATED: 12/16/68
TYPE OF DOC: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

SHEET 1 OF 2 NO CHANGE

SHEET 2 OF 2

FOR CHANGES SEE PAGE 2 OF THIS TDRR

REASON FOR CHANGES

DOCUMENT CORRECTION

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: REF PC/SN R 1069 2003985

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003985
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: REF E. BOWEN
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68; W Stameris 20 Dec 68
MIT CCB APPROVAL: 12-24-68; 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: 12/20/68; 1-10-69; 1/10/69
NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ______ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37186

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P1 (1-68)

R-30689

TDRR NO. 37187

TITLE OF DWG/DOC. INTERCONNECTING DIAGRAM AGC DSKY	CONTRACTOR NO. R-1071	DOC. NO. DASH NO. 2005951	REVISION FROM B	TO C
	MIT ENGINEER E. HALL			
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/17/68	TYPE OF DOC. 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

EQUIP CODE 05

SHEET 2 OF 2 NO CHANGE

SHEET 1 OF 2

1. ADD TO DS2-J11-15 "A1" ZONE 2B

2. ADD THE FOLLOWING TO REFERENCES COL
"7. 2005950 — SIGNAL FLOW DIAGRAM"
8. 2005976 — SIGNAL FLOW DIAGRAM"

FOR ADDITIONAL CHANGES SEE PAGE 2 OF THIS TDRR

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED
REF. PCAN R1069 2003985
R1078; 2005950; R1070
2005976

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED
MIT/RAYTHEON

NEXT HIGHER ASSY
2003985

REMARKS:

DOCUMENT NUMBER REPLACED
N/A

INTERFACE AFFECTED
N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY M. WIKOW X
REF. E BOWEN

DESIGN REVIEW APPROVAL MIT/IL
Edw C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL
M G Mudey 12-24-68 1/10/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
T A Kriofsky Jan 6 '69
E W Hatt 12/20/68
D+P 1-10-69

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

TDRR NO. 37187

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689 **TDRR NO.** 37188
FORM 53-4026 P1 (1-68)

TITLE OF DWG/DOC: AGC DSKY ASSEMBLY

CONTRACTOR NO.: R-1067

MIT ENGINEER: E. HALL

DOC. NO.: 2003994 DASH NO.:

REVISION FROM: G TO: H

SYSTEM OR SUBSYSTEM: AGC BL II

DATE ORIGINATED: 12/11/68

TYPE OF DOC: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

EQUIPCODE 05

B/M

1. ADD QTY REQD -061 SAME AS -041 AND -071 SAME AS -051 WITH THE FOLLOWING EXCEPTIONS: FIND NO REF; PART NO 2005918 FROM "(X)" "(X)" TO "(–)" "(–)" & FIND NO. 2 WHICH IS "–" FOR BOTH
2. ADD TO B/M AS FOLLOWS:

FIND NO	DESCP.	PART NO	-011	-021	-031	-041	-051	-061	-071
37	INDICATOR STATUS/CAUTION	1005025-001	–	–	–	–	–	1	1
REF	SIGNAL FLOW DIAGRAM	2005977	–	–	–	–	–	X	X

REASON FOR CHANGES

TO CALL OUT 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED: REF PC/SN R1077; 1005025 R1070; 2005977

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON

REMARKS:

NEXT HIGHER ASSY: FINAL

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: [illegible] X
REF. E. BOWEN

ENGINEERING APPROVAL MIT/IL:

DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL: [illegible] 12-24-68 1/10/69

CONTRACTOR APPROVAL: TAKrusofsky 10 Jan 69 [illegible] 12/20/68 [illegible] 1-10-69

NASA APPROVAL: NOT REQUIRED CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

TDRR NO. 37189

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P1 (1-68)

PG 1 OF 2
TDRR NO. 37189

TITLE OF DWG/DOC. AGC DSKY ASSEMBLY	CONTRACTOR NO. R-1068 MIT ENGINEER E. HALL	DOC. NO. DASH NO. 2003950	REVISION FROM H	REVISION TO J
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/11/68	TYPE OF DOC. 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

EQUIP CODE 05

B/M

1. ADD QTY REQD -071 COL WITH QTY'S SAME AS -051 WITH THE FOLLOWING EXCEPTIONS: FIND NO. 2 PART NO. 1006387-001 FROM (1) "TO" (–); FIND NO. REF. PART NO. 2005918 : FROM "(X)" "TO" "(–)"

2. ADD TO B/M AS FOLLOWS

FIND NO	DESC	PART NO.	-011	-021	-031	-041	-051	-061	-071
34	INDICATOR STATUS/CAUTION	1005025-001	—	—	—	—	—	—	1
REF.	SIGNAL FLOW DIA	2005977	—	—	—	—	—	—	X

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS CAUTION)

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED
REF. PC/SN R1077: 1005025
R1070: 2005977

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED
MIT/RAYTHEON

NEXT HIGHER ASSY
FINAL

REMARKS:

DOCUMENT NUMBER REPLACED
N/A

INTERFACE AFFECTED
N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY M. Mirow X
REF E BOWEN

DESIGN REVIEW APPROVAL MIT/IL
Eldon C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL
M G Murdy 12-24-68
1/10/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
TA Kriafy 10 Jan 69
12/20/68
1/10/69
1-10-69

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

013

TDRR NO. 37189

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 PI (1-68)

TDRR NO. 37190

TITLE OF DWG/DOC. AGC DSKY ASSEMBLY	CONTRACTOR NO. R-1069	DOC. NO. DASH NO. 2003985	REVISION FROM K	TO L
	MIT ENGINEER E. HALL			
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/13/68	TYPE OF DOC. 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

B/M

1. ADD "-091" QTY REQ'D COL. WITH QTY'S SAME AS -041 WITH THE FOLLOWING EXCEPTIONS: FIND NO. 2 PART NO. 1006316 FROM "(1)" TO "(-)" FIND NO. REF. PART NO. 2005950. FROM "(X)" TO "(-)"

2. ADD TO B/M AS FOLLOWS

FIND NO.	DESC.	PART NO.	-011	-021	-031	-041	-051	-061	-071	-081	-091
46	INDICATOR STATUS/CAU	1005025-001	—	—	—	—	—	—	—	—	1
REF	SIGNAL FLOW DIA	2005976	—	—	—	—	—	—	—	—	X

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CATUTION)

DOC. CLASS A REV. CLASS II	OTHER DOCS. AFFECTED REF: PC/SN R 1077; 1005025 [illegible] 2005976	EFFECTIVITY HARDWARE CUT-IN N/A	CUT-OUT N/A	SPARES

ORGANIZATION AFFECTED MIT/RAYTHEON	NEXT HIGHER ASSY FINAL	DISPOSITION OF PARTS ON HAND: DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
REMARKS:	DOCUMENT NUMBER REPLACED N/A	NO CHANGE			
		MODIFY			
	INTERFACE AFFECTED N/A	SCAP			

PREPARED BY Mirow X REF. F. BOWEN	DESIGN REVIEW APPROVAL MIT/IL Eldon C Hall 12/20/68 W Stameris 20 Dec 1968	MIT CCB APPROVAL 12-24-68 1/10/69
ENGINEERING APPROVAL MIT/IL	CONTRACTOR APPROVAL TA Kruofsky 10 Jan 69 1/10/69 12/20/68	NASA APPROVAL A NOT REQUIRED CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37190

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 PI (1-65)

PG 1 OF 2
TDRR NO. 37191

TITLE OF DWG/DOC.: INTERCONNECTING DIAGRAM AGC DSKY
CONTRACTOR NO.: R-1072
MIT ENGINEER: E. HALL
DOC. NO.: 2005953
DASH NO.:
REVISION FROM: B TO: C
SYSTEM OR SUBSYSTEM: AGC BL II
DATE ORIGINATED: 12/17/68
TYPE OF DOC.: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

SHEET 2 OF 2 NO CHANGE

SHEET 1 OF 2

1. ADD THE FOLLOWING TO REFERENCES COL.
   7. 2005918 - SIGNAL FLOW DIAGRAM
   8. 2005977 - SIGNAL FLOW DIAGRAM

2. ADD J11 DS2 AS SHOWN ON PAGE 2 OF THIS TDRR

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: REF. PC/SN R1068 2005950 R1070 2005977

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003950
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: X
REF E. BOWEN
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68; W Stameris 20 Dec 68
MIT CCB APPROVAL: 12/24/68 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: TA Kurofsky 1 Jan 69 12/20/68 1-10-69 1/10/69
NASA APPROVAL: A NOT REQUIRED CCA497-0278

REISSUE DATE: ________ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37191

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 83-4026 P1 (1-65)

PG 1 OF 2
TDRR NO. 37192

TITLE OF DWG/DOC.: INTERCONNECTING DIAGRAM AGC DSKY
CONTRACTOR NO.: R-1073
MIT ENGINEER: E. HALL
DOC. NO.: 2005954
DASH NO.:
REVISION FROM: A TO: B
SYSTEM OR SUBSYSTEM: AGC BL II
DATE ORIGINATED: 12/17/68
TYPE OF DOC: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

EQUIP CODE 05

SHEET 2 OF 2 NO CHANGE

SHEET 1 OF 2

1. ADD THE FOLLOWING TO REFERENCES COL
" 7. 2005918 — SIGNAL FLOW DIAGRAM"
8. 2005977 — SIGNAL FLOW DIAGRAM"

FOR ADDITIONAL CHANGES SEE PAGE 2 OF THIS TDRR

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC CLASS A
REV. CLASS II

OTHER DOCS AFFECTED: REF. PC/SN R1067; 2003994 R 1070; 2005977

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: 2003994
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: C. Mirow X
REF. E. BOWEN
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 12/20/68
W Stameris 20 Dec 68
MIT CCB APPROVAL: M G Mundy 12-24-68 1/10/69
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: TA Kuofsky 10 Jan 69 12/20/68 1-10-69 1/10/69
NASA APPROVAL: NOT REQUIRED CCA497-0278
REISSUE DATE: ______ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

013

TDRR NO. 37192

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 2
TDRR NO. 37639

TITLE OF DWG/DOC. Spacecraft Installation List - Block II	CONTRACTOR NO.	DOC. NO. 2014999 DASH NO.	REVISION FROM CM TO CN
	MIT ENGINEER		
SYSTEM OR SUBSYSTEM Apollo G&N	DATE ORIGINATED 6-6-69	TYPE OF DOC Drawing 01	

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL
☐ RAYTHEON
☒ AC SPARK
☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. On line titled "Outstanding ECP's Planned For Retrofit"

Add: ECP 790 for G&N 205 (-051), 213 (-131) and 215(-151) thru 222 (-221).
Add: ECP 795 for G&N 205 (-051) and 210 (-101) thru 222 (-221).

2. On table VII - Add the following:

ECP	P/N Change From	To	FIND
795	2012793-000	TBA	107
795	2012700-011	TBA	109
790	2021382-021	TBA	18

REASON FOR CHANGES

To update drawing for latest ECP and system configuration information.

DOC. CLASS A

REV. CLASS II

OTHER DOCS AFFECTED: N/A

EFFECTIVITY N/A

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES

ORGANIZATION AFFECTED: AC Electronics

REMARKS:

NEXT HIGHER ASSY: ND 1000000

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY: E. H. Ekwall

DESIGN REVIEW APPROVAL MIT/IL

MIT CCB APPROVAL 6/9/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL

NASA APPROVAL NOT REQUIRED

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

TDRR NO. 37639

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 2
TDRR NO. 37966

TITLE OF DWG/DOC. K-Start Tape Assembly	CONTRACTOR NO.	DOC. NO. DASH NO. See Below	REVISION FROM -	REVISION TO -
	MIT ENGINEER			
SYSTEM OR SUBSYSTEM Post Installation Testing	DATE ORIGINATED 12-16-69	TYPE OF DOC. 10		

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

DWG 1026293	F10L1300-K10515-0	MATED SYSTEMS C/O
DWG 1026294	F10L1300-K10516-0	STAGED SYSTEMS C/O
DWG 1026295	F10L1300-K10517-0	VALVE SIG PROFILE
DWG 1026296	F10L1300-K10518-0	LM ACA-LGC I/F
DWG 1026297	F10L1300-K10525-0	ROLL/YAW JETS DRYCYCLE
DWG 1026298	F10L1300-K10530-0	LM SAMOD (CDU OPCK)
DWG 1026299	F10L1300-K10531-0	LM G&N OPERATIONAL
DWG 1026700	F10L1300-K10532-0	RCS CWEA-1
DWG 1026701	F10L1300-K10533-0	RCS CWEA-2
DWG 1026702	F10L1300-K10534-0	RCS CWEA-3

[illegible] 55

continued on page 2 of 2

REASON FOR CHANGES
Initial Release

SHIPPING PACKAGE
1. Two (ea) tapes, 1 (ea) card deck, 12 (ea) listings
2. One (ea) Certification and Verification Checklist
3. One (ea) TDRR # 37966

DOC. CLASS A
REV. CLASS -

OTHER DOCS. AFFECTED

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
LM7	LM7	

ORGANIZATION AFFECTED
AC/KSC

NEXT HIGHER ASSY
6014999

REMARKS:
To be used with
LUMINARY 130,
and LUMINARY 131

DOCUMENT NUMBER REPLACED

INTERFACE AFFECTED

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY
R. Lennon

DESIGN REVIEW APPROVAL ~~MIT/IL~~
D A Keenan

~~MIT~~ CCB APPROVAL
12/17/69

ENGINEERING APPROVAL MIT/IL
G. Zeitmeyer 12/16/69

CONTRACTOR APPROVAL

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

TDRR NO. 37966

351

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

TDRR NO. 38516

TITLE OF DWG / DOC. POWER SUPPLY TESTS	CONTRACTOR NO. A 19084	DOC. NO. JDC 14039	REVISION FROM F	REVISION TO G
	MIT ENGINEER			
SYSTEM OR SUBSYSTEM ISS	DATE ORIGINATED 10-11-71	TYPE OF DOC. JDC 09		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 1025 R1

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. Add the following to Step B.1.

l.	28 VDC STBY to PSAAM	299 TPA #2, TB 1-26 (HI) TB5-30 (LO)
m.	28 VDC STBY to PSAAM	299 TPA #2, TB 1-30 (HI) TB5-30 (LO)
n.	28 VDC STBY to PSAAM	299 TPA #2, TB 1-48 (HI) TB5-30 (LO)

REASON FOR CHANGES

Checks 28 VDC standby power to PSAAM interface.

DOC. CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
~~[illegible]~~ N/A.	N/A	N/A

ORGANIZATION AFFECTED: Delco

NEXT HIGHER ASSY: ATP2015497, ND1021043

REMARKS: ~~[illegible]d~~

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: None

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

PREPARED BY: P. Headley

DESIGN REVIEW APPROVAL MIT/IL: 8 Nov 71

~~MIT~~ CCB APPROVAL: 12/6/71

ENGINEERING APPROVAL ~~MIT/IL~~: 11/5/71

CONTRACTOR APPROVAL: 11/24/71

NASA APPROVAL: 12-3-71

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

340

WA 984208

TDRR NO. 38516

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 2
TDRR NO. 38519

TITLE OF DWG / DOC.: SUBSYSTEM MODE TESTS (PREVIBRATION)
CONTRACTOR NO.: A 19087
MIT ENGINEER:
DOC. NO.: JDC 16106
REVISION FROM: F TO: G
SYSTEM OR SUBSYSTEM: ISS
DATE ORIGINATED: 10-11-71
TYPE OF DOC.: JDC 09

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 1025 R1

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. Add the following after Step B. 20:

20.a Set the CAGE switch on the CDU shorting connector to the TEST position.

20.b Close the OG Cage Loop by pressing the OG DRIVE INHIBIT pushbutton on the Test Control panel.

20.c Monitor the PAVM and record the total value of the OG torque motor voltage.

20.d Open the OG Loop by pressing the OG DRIVE INHIBIT pushbutton.

20.e Set the CAGE switch on the CDU shorting connector to the NORMAL position.

REASON FOR CHANGES

Verify coarse Align input signal lines to the Servo Amps.

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY
HARDWARE CUT-IN: N/A
HARDWARE CUT-OUT: N/A
SPARES: N/A

ORGANIZATION AFFECTED: Delco
NEXT HIGHER ASSY: ATP2015497, ATP 6015497 ~~ND 1021042, ND 1021043~~

REMARKS: ~~*No retest required~~
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: None

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

PREPARED BY: P. Headley
DESIGN REVIEW APPROVAL MIT/IL: W Stameris 8 Nov 71
~~MIT~~ CCB APPROVAL: 12/1/71
ENGINEERING APPROVAL ~~MIT/IL~~: Jones 11/5/71
CONTRACTOR APPROVAL: 11/24/71
NASA APPROVAL:
REISSUE DATE: ______ REASON:
12-3-71
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

TDRR NO. 38519

W A 984208

PG 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

TDRR NO. 38600

TITLE OF DWG/DOC: FLOAT ASSEMBLY APOLLO II IRIG
CONTRACTOR NO.: PPD-15
MIT ENGINEER:
DOC NO / DASH NO.: 2021619
REVISION FROM: P TO: R
SYSTEM OR SUBSYSTEM: APOLLO II IRIG
DATE ORIGINATED: 11/24/71
TYPE OF DOC.: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ ECP NO. ________

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC SPARK ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. Add -121 Assy. to note 2 as follows: "assemble per ND 1002459 and ND 1002464 OR ND1002475 AND ND1002464, 2021619-111 & 121 Configurations only".
2. Add -121 Assy. to note 9 as follows: "test per ~~ND 1002460~~ ND1002459 OR ND1002475, 2021619-111 and 121 Configurations only".
3. Add a new assembly as shown on page 2 of this TDRR.
4. Add (24) onto inertia element assembly in section Z-Z.
5. Add (24) to selection list in note 6.

~~6. In note 9 change ND 1002460 to ND 1002459 or ND 1002475.~~

~~7. In note 2 add "or ND 1002475 and ND 1002464" just before 2021619.~~

REASON FOR CHANGES

Incorporate 2021830 Retainer design in Northrop Build units.

DOC. CLASS: A
REV. CLASS: 2
OTHER DOCS. AFFECTED: 2021611
HARDWARE EFFECTIVITY: CUT-IN: N/A CUT-OUT: N/A
SPARES EFFECTIVITY:
ORGANIZATION AFFECTED: NORTHROP
NEXT HIGHER ASSY: 2021611
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

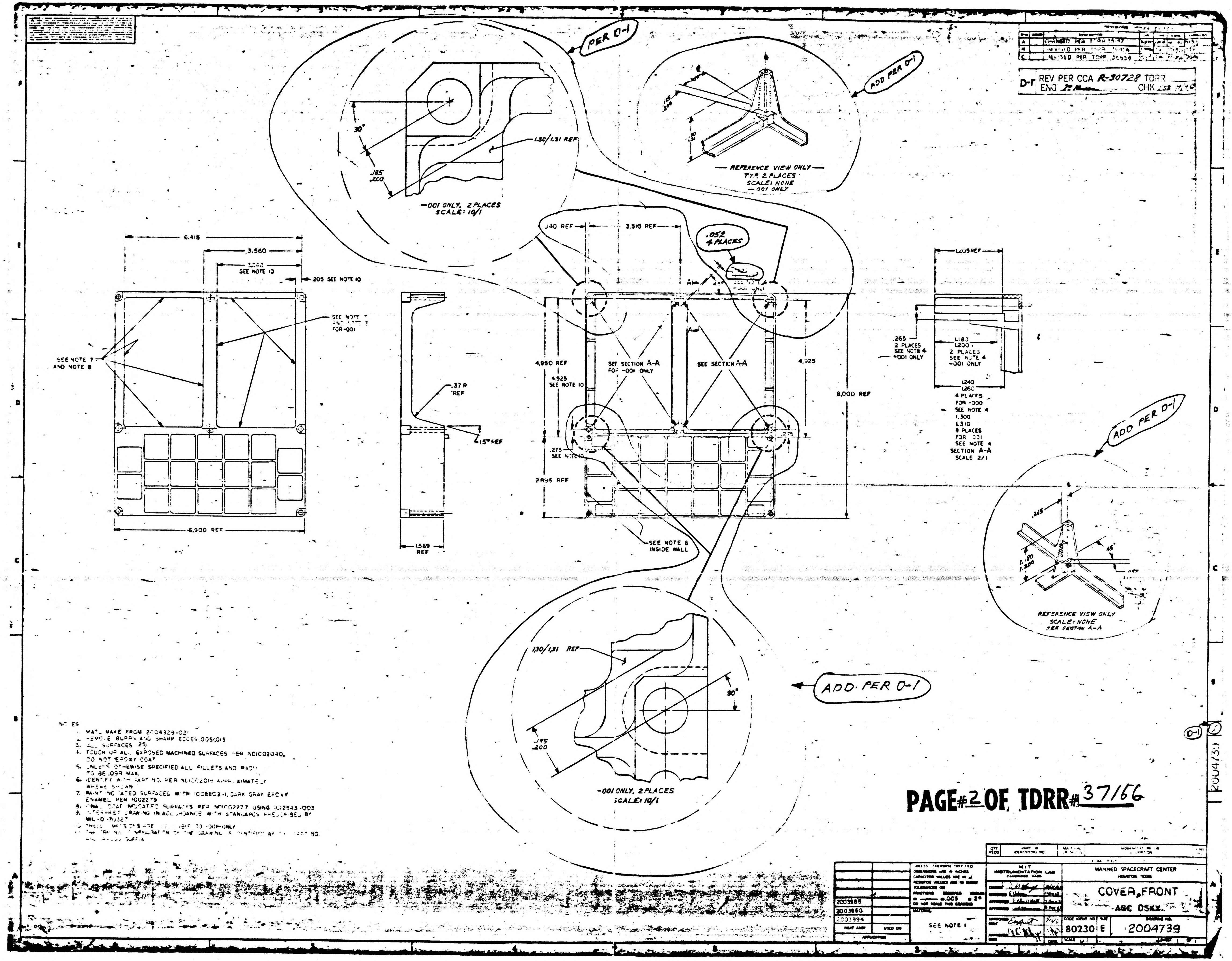
PREPARED BY: T. Grant 11/24/71
DESIGN REVIEW APPROVAL MIT/IL: N/A
MIT CCB APPROVAL: 2/22/72
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL: VEHaut 11-1-71
A. Bagni PPD QA 12/1/71
NASA APPROVAL: 2-14-72
REISSUE DATE: ________ REASON:
CCB INITIAL
MIT-
CONTR-
NASA-

067

TP8913 (REV.1/65)

W.A. 933760

TDRR NO. 38600


PER D-1
1.30/1.31 REF
30°
.185
.200
-001 ONLY, 2 PLACES
SCALE: 10/1
ADD PER D-1
REFERENCE VIEW ONLY
TYP. 2 PLACES
SCALE: NONE
-001 ONLY
6.418
3.560
3.060
SEE NOTE 10
.205 SEE NOTE 10
SEE NOTE 7 AND NOTE 8
SEE NOTE 7 AND NOTE 8 FOR -001
6.900 REF
.37 R REF
15° REF
1.569 REF
.140 REF
3.310 REF
.052
4 PLACES
SEE NOTE 10
-001 ONLY
A
SEE SECTION A-A FOR -001 ONLY
SEE SECTION A-A
4.950 REF
4.925
SEE NOTE 10
4.925
8.000 REF
.275
SEE NOTE 10
.275
2.895 REF
SEE NOTE 6
INSIDE WALL
1.205 REF
.265
2 PLACES
SEE NOTE 4
-001 ONLY
1.180
1.200
2 PLACES
SEE NOTE 4
-001 ONLY
1.240
1.260
4 PLACES
FOR -000
SEE NOTE 4
1.300
1.310
8 PLACES
FOR -001
SEE NOTE 4
SECTION A-A
SCALE 2/1
ADD PER D-1
.265
1.180
1.200
45°
REFERENCE VIEW ONLY
SCALE: NONE
SEE SECTION A-A
1.30/1.31 REF
30°
.185
.200
-001 ONLY, 2 PLACES
SCALE: 10/1
ADD PER D-1
D-1
2004739

A		CHANGED PER TDRR [illegible]				
B		REVISED PER TDRR [illegible]				
C		REVISED PER TDRR [illegible]				

D-1 REV PER CCA R-30728 TDRR
ENG
CHK

NOTES
1. MATL MAKE FROM 2004929-021
2. REMOVE BURRS AND SHARP EDGES .005/.015
3. ALL SURFACES 125/
4. TOUCH UP ALL EXPOSED MACHINED SURFACES PER ND1002040. DO NOT EPOXY COAT
5. UNLESS OTHERWISE SPECIFIED ALL FILLETS AND RADII TO BE .09R MAX.
6. IDENTIFY WITH PART NO. PER ND1002019 APPROXIMATELY WHERE SHOWN
7. PAINT INDICATED SURFACES WITH 1008803-1, DARK GRAY EPOXY ENAMEL PER 1002279
8. FINAL COAT INDICATED SURFACES PER ND1002277 USING 1012543-003
9. INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327
10. THESE DIMENSIONS ARE APPLICABLE TO -001 ONLY
11. THE ORIGINAL CONFIGURATION OF THE DRAWING IS IDENTIFIED BY THE PART NO. AND [illegible] SUFFIX

PAGE # 2 OF TDRR # 37166

2003985	
2003980	
2003994	
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITOR VALUES ARE IN µf
RESISTOR VALUES ARE IN OHMS
TOLERANCES ON
FRACTIONS ± — DECIMALS ± .005 ANGLES ± 2°
DO NOT SCALE THIS DRAWING

MATERIAL
SEE NOTE 1

MIT
INSTRUMENTATION LAB
CAMBRIDGE, MASS.

DRAWN
CHECKED
APPROVED
APPROVED
APPROVED
APPROVED

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

COVER, FRONT
AGC DSKY

CODE IDENT NO 80230
SIZE E
DRAWING NO. 2004739
SCALE
SHEET 1 OF 1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION M00430

PG 2 OF 2
TDRR NO. 36992

TITLE OF DWG/DOC.	DOC. NO. / DASH NO.	REVISION FROM	REVISION TO
MULTIPLE RELEASE OF ICD'S	ICD'S & IRN'S		

EQUIP CODE

DESCRIPTION OF CHANGES / ZONE

76 4. ICD LIS-410-10003 REV A "POWER & SERVO ASSEMBLY (PSA) ADAPTER MODULE ELECTRICAL INTERFACE (14 SHEETS)

76 5. IRN LID-280-10004 A-7 AGAINST ICD LID-280-10004 REV. A "IMU-AOT-NVB-PTA INSTALLATION" (1 SHEET)

76 6. IRN LID-280-10004A-6 AGAINTS ICD LID-280-10004 REV. A "IMU-AOT-NVB-PTA INSTALLATION" (1 SHEET)

75 7. ICD MH01-01388-416 REV A "INTERIOR LIGHTING FUNCTIONAL PERFORMANCE CRITERIA (21 SHEETS).

75 8. ICD MH01-01327-216 REV A "GUIDANCE & NAVIGATION ELECTRICAL INPUT POWER BLOCK II MIT NAA (11 SHEETS)

75 9. IRN 629~~1~~2 AGAINST ICD MH01-01380-216 REV B "CMC ELECTRICAL INTERFACE" (1 SHEET) *

75 10. IRN 6342 AGAINST ICD MH01-01388-416 "INTERIOR LIGHTING FUNCTIONAL PERFORMANCE CRITERIA (3 SHEETS)

75 11. IRN 6357 AGAINST ICD MH01-05174-414 REV C "NOMENCLATURE, MARKINGS & COLOR (1 SHEET)

TP 8913

PG 2 OF 2

TDRR NO. 37171

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
Spacecraft Installation List - Block II	2014999	BT	BU

DESCRIPTION OF CHANGES **ZONE**

4. Add new FIND as follows:

Qty	Nomenclature or Description	Remarks	Equip. Code	FIND No.
1	G&N TVC ALT Test	See Note 11	55	160

5. In FIND No. 160 - Add P/N "1026209 Rev-" for G&N System 206(-061).

6. FIND No. 140 - Change P/N "1026516 Rev. C" to "1026516 Rev. K" for G&N System 208(-081).

7. FIND No. 141 - Change P/N "1026517 Rev. C" to "1026517 Rev. D" for G&N System 208(-081).

8. FIND No. 4 - Change P/N "2021104-041" to"2021108-021" for G&N System 206(-061).

9. Add the following information for FIND No's. 46 and 47:

Qty	Nomenclature or Description	Remarks	Equip. Code	FIND No.
1	SCT LER Eyepiece High Density Filter Assy.		65	47
1	SCT STD Eyepiece High Density Filter Assy.		65	46

10. FIND No. 46 - Add "P/N 2012808-000" for G&N Systems 205(-051), 206(-061), and 208(-081) through 222(-221).

11. FIND No. 47 - Add "P/N 2012816-000" for G&N Systems 205(-051), 206(-061), and 208(-081) through 222(-221).

TP 8913

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 2
TDRR NO. 37172

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
Spacecraft Installation List - LEM	6014999	BC	BD

DESCRIPTION OF CHANGES — **ZONE**

5. Add FIND No. 160 as follows:

Qty.	Nomenclature or Description	Remarks	Equip. Code	FIND No.
1	LM SAMOD (CDU OPCHK)	See Note 8	55	160

6. Add part numbers for G&N systems 606 (-061) and 609 (-091) as follows:

FIND No. 130 - Add P/N "1026214 Rev-"
FIND No. 147 - Add P/N "1026222 Rev-"
FIND No. 148 - Add P/N "1026221 Rev-"
FIND No. 149 - Add P/N "1026210 Rev-"
FIND No. 150 - Add P/N "1026211 Rev-"
FIND No. 151 - Add P/N "1026212 Rev-"
FIND No. 153 - Add P/N "1026216 Rev. -"
FIND No. 154 - Add P/N "1026217 Rev-"
FIND No. 155 - Add P/N "1026218 Rev-"
FIND No. 156 - Add P/N "1026219 Rev-"
FIND No. 157 - Add P/N "1026220 Rev-"
FIND No. 158 - Add P/N "1026213 Rev-"
FIND No. 160 - Add P/N "1026215 Rev-"

7. FIND No. 147 - Change Nomenclature or description
From: "RCS C & N I/F"
To: "RCS C & W I/F"

TP 0913

TDRR NO. 37172

PG 2 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689 TDRR NO. 37181
FORM 53-4026 P2 (1-66)

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
P.S. DSKY DWG NO. 2003994	PS. 2003994		J	K

DESCRIPTION OF CHANGES

ZONE

3. ADD TO TABLE 3-3 AS FOLLOWS

LOGIC INPUT	J9 INPUT PIN	INDICATOR ILLUMINATED	CONTACT CLOSURE BETWEEN PINS
0	66		56 AND 16
1	66		56 AND 23

4. CHANE PARA 5.1 FROM " GENERAL. PREPARATION FOR DELIVERY SHALL BE IN ACCORDANCE WITH SPECIFICATION NO 1002214. THE ASSEMBLY SHALL BE PRESSURIZED TO .7 TO 1.5 PSIG." TO " GENERAL. PREPARATION FOR DELIVERY SHALL BE IN ACCORDANCE WITH SPECIFICATION NO 1002214. THE ASSEMBLY SHALL BE PRESSURIZED TO 2 ± 1/2 PSIG."

TP8913

TDRR NO. 37181

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P2 (1-65)

R- 30689

PG 2 OF 2
TDRR NO. 37184

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
INDICATOR STATUS/CAUTION SCD	1005025		—	A

DESCRIPTION OF CHANGES

ZONE

SHEET 3 OF 3

3. CHANGE CALLOUT IN ZONE 1C FROM "INSULATOR 1006775(30) CONTACT MALE 1006782(30)" TO "INSULATOR 1006775(30) CONTACT MALE 1006782-1(30)"

TP 8913

TDRR NO. 37184

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P2 (1-66)

E-30689

PG 2 OF 2
TDRR NO. 37186

TITLE OF DWG/DOC. SIGNAL FLOW DIAGRAM AGC DSKY	DOC. NO. 2005950	DASH NO.	REVISION FROM C TO D

DESCRIPTION OF CHANGES

ZONE

1. CHANGE CHART IN ZONE '1A' FROM

ALARM DISPLAY CODE TABLE (SEE NOTE 2)			
UPLINK ACTY	DS201	TEMP	DS214
AUTO	DS202	GIMBAL LOCK	DS213
HOLD	DS203	PROG	DS212
FREE	DS204	RESTART	DS211
NO ATTITUDE	DS205	TRACKER	DS210
STBY	DS206	SPARE	DS209
KEY REL	DS207	OPR ERR	DS208

TO.

	ALARM DISPLAY CODE TABLE (SEE NOTE 2)				
	UPLINK ACTY	DS201	TEMP	DS214	
*	AUTO	DS202	GIMBAL LOCK	DS213	
*	HOLD	DS203	PROG	DS212	
*	FREE	DS204	RESTART	DS211	
	NO ATTITUDE	DS205	TRACKER	DS210	
	STBY	DS206	SPARE	DS209	*
	KEY REL	DS207	OPR ERR	DS208	

* NOTE: FOR 2003985-061&-081 CONFIGURATIONS
DS202, DS203, DS204 & DS209 ARE NOT USED.

TP 6913

TDRR NO. 37186

2005951 B

C-1

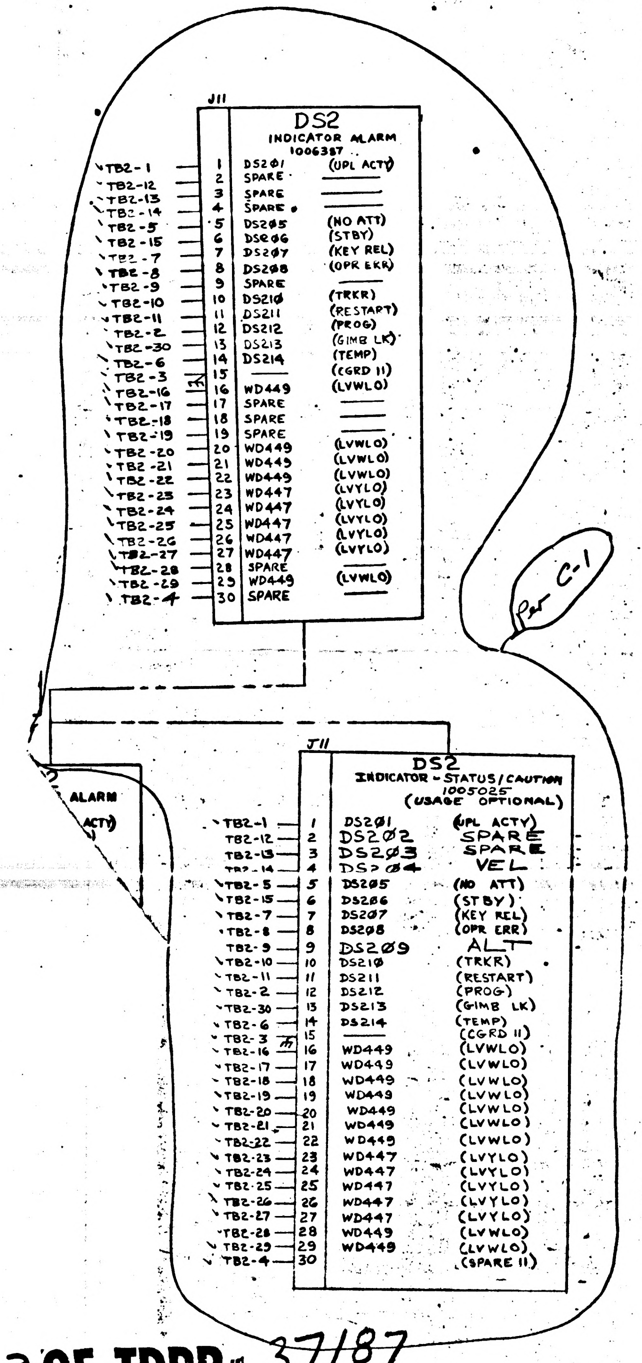
REVISIONS 20743

SYM	DESCRIPTION	DATE	APPROVAL
A	REVISED PER TDRR 22164 DR CHK APPD	9/13/65	
B	REVISED PER TDRR 24667 DR C. Barbee CHK APPD	12/30/65	

C-1 REV PER CCA R-30689 TDRR
ENG S.B. Bowen / R.K. CHK

No change – sheet 2

D



J11

DS2
INDICATOR ALARM
1006387

	Pin		
TB2-1	1	DS201	(UPL ACTY)
TB2-12	2	SPARE	
TB2-13	3	SPARE	
TB2-14	4	SPARE	
TB2-5	5	DS205	(NO ATT)
TB2-15	6	DS206	(STBY)
TB2-7	7	DS207	(KEY REL)
TB2-8	8	DS208	(OPR ERR)
TB2-9	9	SPARE	
TB2-10	10	DS210	(TRKR)
TB2-11	11	DS211	(RESTART)
TB2-2	12	DS212	(PROG)
TB2-30	13	DS213	(GIMB LK)
TB2-6	14	DS214	(TEMP)
TB2-3	15		(CGRD II)
TB2-16	16	WD449	(LVWLO)
TB2-17	17	SPARE	
TB2-18	18	SPARE	
TB2-19	19	SPARE	
TB2-20	20	WD449	(LVWLO)
TB2-21	21	WD449	(LVWLO)
TB2-22	22	WD449	(LVWLO)
TB2-23	23	WD447	(LVYLO)
TB2-24	24	WD447	(LVYLO)
TB2-25	25	WD447	(LVYLO)
TB2-26	26	WD447	(LVYLO)
TB2-27	27	WD447	(LVYLO)
TB2-28	28	SPARE	
TB2-29	29	WD449	(LVWLO)
TB2-4	30	SPARE	

J11

DS2
INDICATOR – STATUS/CAUTION
1005025
(USAGE OPTIONAL)

	Pin		
TB2-1	1	DS201	(UPL ACTY)
TB2-12	2	DS202	SPARE
TB2-13	3	DS203	SPARE
TB2-14	4	DS204	VEL
TB2-5	5	DS205	(NO ATT)
TB2-15	6	DS206	(STBY)
TB2-7	7	DS207	(KEY REL)
TB2-8	8	DS208	(OPR ERR)
TB2-9	9	DS209	ALT
TB2-10	10	DS210	(TRKR)
TB2-11	11	DS211	(RESTART)
TB2-2	12	DS212	(PROG)
TB2-30	13	DS213	(GIMB LK)
TB2-6	14	DS214	(TEMP)
TB2-3	15		(CGRD II)
TB2-16	16	WD449	(LVWLO)
TB2-17	17	WD449	(LVWLO)
TB2-18	18	WD449	(LVWLO)
TB2-19	19	WD449	(LVWLO)
TB2-20	20	WD449	(LVWLO)
TB2-21	21	WD449	(LVWLO)
TB2-22	22	WD449	(LVWLO)
TB2-23	23	WD447	(LVYLO)
TB2-24	24	WD447	(LVYLO)
TB2-25	25	WD447	(LVYLO)
TB2-26	26	WD447	(LVYLO)
TB2-27	27	WD447	(LVYLO)
TB2-28	28	WD449	(LVWLO)
TB2-29	29	WD449	(LVWLO)
TB2-4	30		(SPARE II)

C

B

C-1

2005951 B

PAGE #2 OF TDRR# 37187

A

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	FIND NO

LIST OF MATERIALS

MIT
INSTRUMENTATION LAB
Cambridge Mass

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

DRAWN R.C. Taylor DATE
CHECKED
APPROVAL
APPROVAL

INTERCONNECTING DIAGRAM
AGC DSKY

NASA APPROVAL
MIT APPROVAL

CODE IDENT NO. 80230
SIZE J
NASA DRAWING NO 2005951
SCALE NONE
WT
SHEET 1 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P2 (1-65)

PG. 2 OF 2
TDRR NO. 37188

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
AGC DSKY ASSEMBLY	2003994		G	H

DESCRIPTION OF CHANGES

ZONE

2. ADD TO NOTE APPLICATION CHART AS FOLLOWS

NOTE APPLICATION	
DASH NO.	APPLICABLE NOTES
-061	1 THRU 12, 15, 18
-071	1 THRU 12, 15, 18

FRONT VIEW

3. ADD FIND NO 37 BALLOON CALL OUT TO FIND NO 2 & 28 BALLOON CALLOUT IN ZONE 5C

NOTES

4. CHANGE NOTE 15 FROM " THE -011, & -041 CONFIGURATION SHALL REFLECT A NOMENCLATURE AS SHOWN, THE, -021, -031, & -051, CONFIGURATION SHALL REFLECT " PRO " IN KEY POSITION INDICATED. " TO " THE -011, -041 & -061 CONFIGURATION SHALL REFLECT A NOMENCLATURE AS SHOWN, THE -021, -031, -051 & -071 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION. "

5. ADD TO NOTE 8 AS FOLLOWS " USE PS 2016041 FOR -061 & -071 "

SECTION C-C

6. CHANGE REF FROM " -041 & -051 ONLY " TO " -041, -051, -061 & -071 "

TP 8913

TDRR NO. 37188

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P2 (1-65)

PG 2 OF 2
TDRR NO. 37189

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
AGC DSKY ASSEMBLY	2003950		H	J

DESCRIPTION OF CHANGES

ZONE

NOTE APPLICATION CHART.

3. ADD TO CHART AS FOLLOWS: DASH NO: -071: APPLICABLE NOTES: 1 THRU 5, 7 THRU 12, 14"

SECTION C-C

4. CHANGE REF FROM "-041 & -051 & -061 ONLY" TO "-041, -051, -061 & -071"

FRONT VIEW

5. ADD FIND NO. 34 BALLOON CALLOUT TO FIND NO'S 33, 29 & 2 BALLOON CALLOUTS IN ZONE 5C.

NOTES

6. CHANGE NOTE 14 FROM "THE -011, -021, -041 & 051 CONFIGURATION SHALL REFLECT A NOMENCLATURE AS SHOWN, THE -031 & -061 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION INDICATED" TO "THE -011, -021 -041, -051 & 071 CONFIGURATION SHALL REFLECT A NOMENCLATURE AS SHOWN, THE -031 & -061 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION INDICATED."

7. ADD TO NOTE 2 AS FOLLOWS "EXCEPT USE PS 2016037 FOR -071"

TP 8913

PG 2 OF 2

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P2 (1-65)

R-30689

TDRR NO. 37190

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
AGC DSKY ASSEMBLY	2003985		K	L

DESCRIPTION OF CHANGES | ZONE

NOTE APPLICATION CHART

3. CHANGE NOTES APPLICABLE FOR DASH NO'S -011 THRU -041 FROM "1 THRU 13, AND 15." TO "1 THRU 13, 15 & 16".

4. ADD DASH NO "-091" NOTES APPLICABLE "1 THRU 13, 15, AND 16."

~~SECTION [illegible]~~

~~5. CHANGE [illegible] FROM "[illegible] & -081 ONLY" TO "[illegible] -051 & -091"~~

FRONT VIEW

6. ADD FIND NO 46 BALLOON CALLOUT TO FIND NO. 45, 41, & 2 BALLOON CALLOUTS IN ZONE 5C."

NOTES

7. ADD TO NOTE 9 "USE PS2016039 FOR -091."

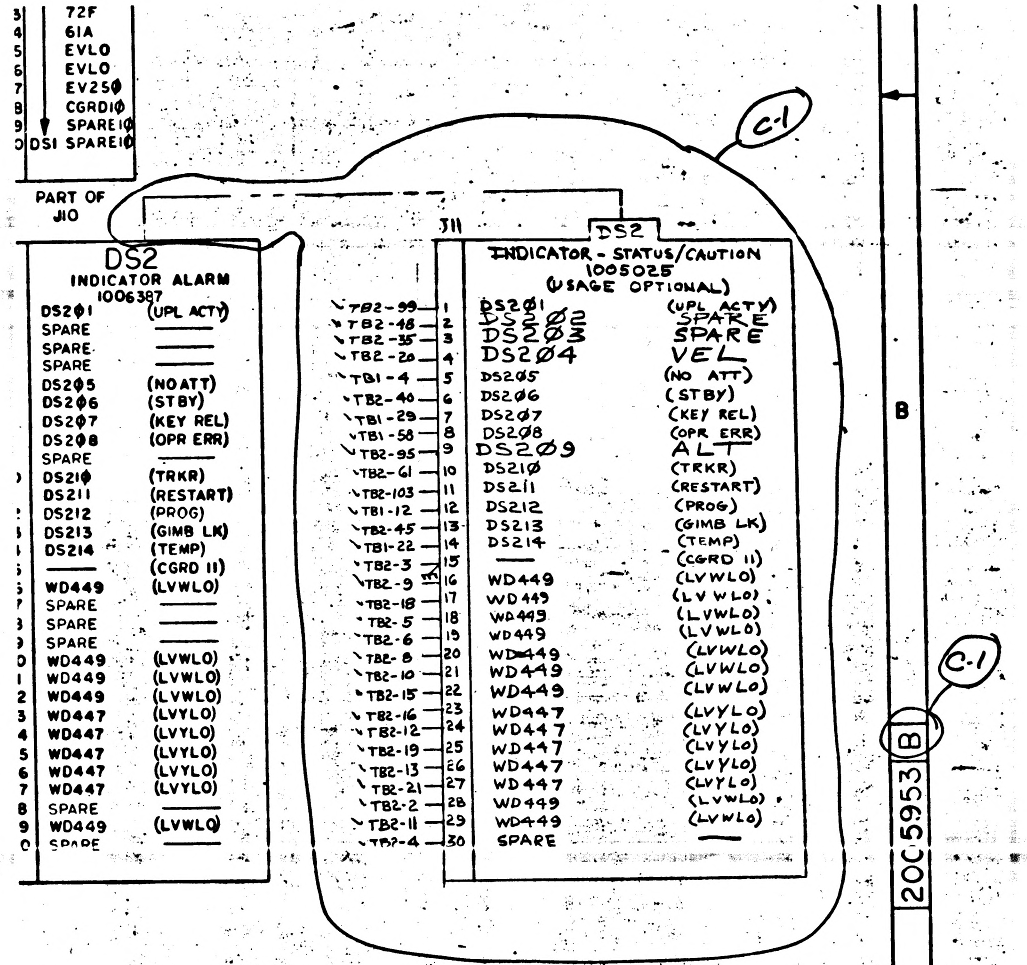
8. CHANGE IN NOTE 13 FROM "INSULATATORS" TO "INSULATORS"

9. CHANGE NOTE 15 FROM "THE -011, -021, -031, -041, -051 & -071 CONFIGURATIONS SHALL REFLECT A NOMENCLATURE AS SHOWN. THE -061 & -081 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION INDICATED" TO "THE -011, -021, -031, -041, -051, -071 & -091 CONFIGURATIONS SHALL REFLECT A NOMENCLATURE AS SHOWN. THE -061 & -081 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION INDICATED."

10. ADD TO NOTE 16 AS FOLLOWS "THE -091 CONFIGURATION SHALL EXHIBIT 14 STATUS/CAUTION LEGENDS ON FIND NO. 46."

TP 8913

TDRR NO. 37190


72F
61A
EVLO
EVLO
EV250
CGRD10
SPARE10
DS1 SPARE10
PART OF J10
DS2
INDICATOR ALARM
1006387
DS201 (UPL ACTY)
SPARE
SPARE
SPARE
DS205 (NO ATT)
DS206 (STBY)
DS207 (KEY REL)
DS208 (OPR ERR)
SPARE
DS210 (TRKR)
DS211 (RESTART)
DS212 (PROG)
DS213 (GIMB LK)
DS214 (TEMP)
(CGRD 11)
WD449 (LVWLO)
SPARE
SPARE
SPARE
WD449 (LVWLO)
WD449 (LVWLO)
WD449 (LVWLO)
WD447 (LVYLO)
WD447 (LVYLO)
WD447 (LVYLO)
WD447 (LVYLO)
WD447 (LVYLO)
SPARE
WD449 (LVWLO)
SPARE
J11
DS2
INDICATOR - STATUS/CAUTION
1005025
(USAGE OPTIONAL)
TB2-99 1 DS201 (UPL ACTY)
TB2-48 2 DS202 SPARE
TB2-35 3 DS203 SPARE
TB2-20 4 DS204 VEL
TB1-4 5 DS205 (NO ATT)
TB2-40 6 DS206 (STBY)
TB1-29 7 DS207 (KEY REL)
TB1-58 8 DS208 (OPR ERR)
TB2-95 9 DS209 ALT
TB2-61 10 DS210 (TRKR)
TB2-103 11 DS211 (RESTART)
TB1-12 12 DS212 (PROG)
TB2-45 13 DS213 (GIMB LK)
TB1-22 14 DS214 (TEMP)
TB2-3 15 (CGRD 11)
TB2-9 16 WD449 (LVWLO)
TB2-18 17 WD449 (LVWLO)
TB2-5 18 WD449 (LVWLO)
TB2-6 19 WD449 (LVWLO)
TB2-8 20 WD449 (LVWLO)
TB2-10 21 WD449 (LVWLO)
TB2-15 22 WD449 (LVWLO)
TB2-16 23 WD447 (LVYLO)
TB2-12 24 WD447 (LVYLO)
TB2-19 25 WD447 (LVYLO)
TB2-13 26 WD447 (LVYLO)
TB2-21 27 WD447 (LVYLO)
TB2-2 28 WD449 (LVWLO)
TB2-11 29 WD449 (LVWLO)
TB2-4 30 SPARE
C-1
C-1
B
2005953 B

PAGE#2 OF TDRR# 37191

A

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	FIND NO

LIST OF MATERIALS

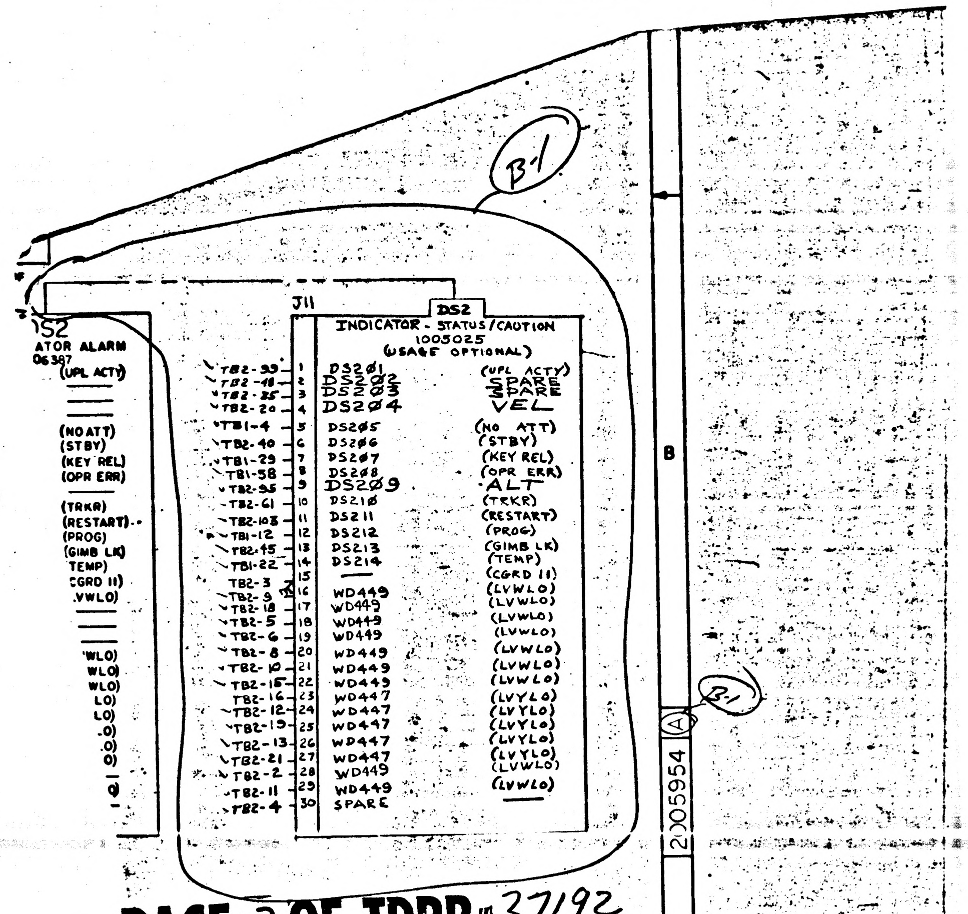
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± DECIMALS ± ANGLES ±
DO NOT SCALE THIS DRAWING
MATERIAL
HEAT TREATMENT
FINAL FINISH
USED ON

MIT
INSTRUMENTATION LAB
CAMBRIDGE MASS
DRAWN DATE 21 DEC
CHECKED
APPROVAL
APPROVAL
NASA APPROVAL

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

INTERCONNECTING DIAGRAM
AGC DSKY

CODE IDENT NO. 80230
SIZE J
NASA DRAWING NO 2005953
SHEET 1 OF 2


B-1
J11
DS2
INDICATOR - STATUS/CAUTION
1005025
(USAGE OPTIONAL)
TB2-39 1 DS201 (UPL ACTY)
TB2-48 2 DS202 SPARE
TB2-35 3 DS203 SPARE
TB2-20 4 DS204 VEL
TB1-4 5 DS205 (NO ATT)
TB2-40 6 DS206 (STBY)
TB1-29 7 DS207 (KEY REL)
TB1-58 8 DS208 (OPR ERR)
TB2-95 9 DS209 ALT
TB2-61 10 DS210 (TRKR)
TB2-103 11 DS211 (RESTART)
TB1-12 12 DS212 (PROG)
TB2-45 13 DS213 (GIMB LK)
TB1-22 14 DS214 (TEMP)
15 (CGRD 11)
TB2-3 16 WD449 (LVWLO)
TB2-9 17 WD449 (LVWLO)
TB2-18 18 WD449 (LVWLO)
TB2-5 19 WD449 (LVWLO)
TB2-6 20 WD449 (LVWLO)
TB2-8 21 WD449 (LVWLO)
TB2-10 22 WD449 (LVWLO)
TB2-15 23 WD447 (LVYLO)
TB2-16 24 WD447 (LVYLO)
TB2-12 25 WD447 (LVYLO)
TB2-19 26 WD447 (LVYLO)
TB2-13 27 WD447 (LVYLO)
TB2-21 28 WD449 (LVWLO)
TB2-2 29 WD449 (LVWLO)
TB2-11 30 SPARE
TB2-4
DS2
ATOR ALARM
06387
(UPL ACTY)
(NO ATT)
(STBY)
(KEY REL)
(OPR ERR)
(TRKR)
(RESTART)
(PROG)
(GIMB LK)
TEMP)
CGRD 11)
VWLO)
WLO)
WLO)
WLO)
LO)
LO)
O)
O)
O)
B
A
2005954
B-1

PAGE#2 OF TDRR#37192

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	FIND NO

LIST OF MATERIALS

MIT INSTRUMENTATION LAB
CAMBRIDGE MASS

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

DRAWN Cardono DATE 10/3/66
CHECKED A. Kiefer 4 OCT 66
APPROVAL
APPROVAL Eldon C Hall 10 Oct 66
NASA APPROVAL
C&A APPROVAL 1/6/67

INTERCONNECTING DIAGRAM
AGC DSKY

CODE IDENT NO 80230
SIZE J
NASA DRAWING NO 2005954
SCALE NONE
WT
SHEET 1 OF 2

A

2005954

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 2
TDRR NO. 37639

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
Spacecraft Installation List - Block II	2014999	CM	CN

DESCRIPTION OF CHANGES — ZONE

3. Change/Add the following part numbers for G&N 202 (-021).

   FIND No. 105 - Change "2012790-011" to "2012790-000"
   FIND No. 106 - Change "2012699-000" to "2012791-000"
   FIND No. 107 - Chnage "2012719-000" to "2012793-000"
   FIND No. 108 -Change "2012667-000" to "2012775-000"
   FIND No. 110 - Add "1011787-000"

4. Add the following part numbers for G&N 210 (-101).

   FIND No. 11 - Add "2021484"
   FIND No. 24 - Add "2021473"
   FIND No. 31 - Add "2021479-011"

5. FIND No. 2 - Change P/N "2003993-061" to "2003993-041" for G&N 218 (-181).

6. FIND No. 4 - Delete P/N "2021111-041" from G&N 210 (-101).

7. FIND No. 10 - Add P/N "2003972-861, 1031, 881, 891, 911, 921" for G&N 210 (-101).

8. Change/Add the following part numbers for G&N 210 (-101).

   FIND No. 140 - Change "1026552 Rev. -" to "1026576 Rev. A"
   FIND No. 141 - Change "1026553 Rev. -" to "1026577 Rev. -"
   FIND No. 142 - Change "1026554 Rev. -" to "1026578 Rev. -"
   FIND No. 143 - Add "1026567 Rev.-"

9. Add new FIND as follows:

QTY.	Nomenclature or Description	Remarks	Equip. Code	FIND
1	ALARMS & INTERRUPTS TEST	See NOTE 11	55	165

   Add part number "1026251 Rev. -" for G&N 210 (-101).

10. FIND No. 143 - Change P/N "1026534 Rev. -" to "1026534 Rev. A" for G&N 209 (-091).

TP 8913

TDRR NO. 37639

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 2
TDRR NO. 37966

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
K-Start Tape Assembly	See Below	-	-

DESCRIPTION OF CHANGES

DWG 1026703	F10L1300-K10535-0	LM FDAI TOT-ATT/ATT-ERR
DWG 1026704	F10L1300-K10536-0	FWD-LAT/ALT-ALT RATE
DWG 1026705	F10L1300-K10538-0	LGC SELF-TEST
DWG 1026706	F10L1300-K10539-0	RCS C&W I/F
DWG 1026708	F10L1300-K10546-0	LR DATA ACCURACY READ TEST
DWG 1026707	F10L1300-K10545-0	ALARMS AND INTERRUPTS
DWG 1026709	F10L1300-K10550-0	ALMS & INT TEST/RSTRT MON
DWG 1026713	F10L1300-K10549-0	RR CDU I/F TEST

ZONE

TP 6912

TDRR NO. 37966

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 2
TDRR NO. 38516

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
POWER SUPPLY TESTS	JDC 14039	F	G

DESCRIPTION OF CHANGES

ZONE

2. Add the following steps after Step B.1.k on the data sheet.

B.1.l	28 VDC STBY to PSAAM	Volts	27.8		28.8		
B.1.m	28 VDC STBY to PSAAM	Volts	27.8		28.8		
B.1.n	28 VDC STBY to PSAAM	Volts	27.8		28.8		

TP 8913

TDRR NO. 38516

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 2
TDRR NO. 38519

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
SUBSYSTEM MODE TESTS (PREVIBRATION)	JDC 16106	F	G

DESCRIPTION OF CHANGES **ZONE**

2. Add the following after Step B. 29:

29.a Set the CAGE switch on the CDU Shorting Connector to the TEST position.

29.b Close the MG Cage Loop by pressing the MG DRIVE INHIBIT pushbutton on the Test Control panel.

29.c Monitor the PAVM and record the total value of the MG torque motor voltage.

29.d Open the MG Loop by pressing the MG DRIVE INHIBIT pushbutton.

3. Add the following after Step B. 38:

38.a Set the CAGE switch on the CDU Shorting Connector to the TEST position.

38.b Close the IG Cage Loop by pressing the IG DRIVE INHIBIT pushbutton on the Test Control panel.

38.c Monitor the PAVM and record the total value of the IG torque motor voltage.

38.d Open the IG Loop by pressing the IG DRIVE INHIBIT pushbutton.

38.e Set the CAGE switch on the CDU Shorting Connector to the NORMAL position.

4. Add the following steps to the data sheets in the appropriate positions.

B. 20. c	Total OG Torque Motor Voltage	Volts	▨		10		
B. 29. c	Total MG Torque Motor Voltage	Volts	▨		10		
B. 38. c	Total IG Torque Motor Voltage	Volts	▨		10		

TP 8913

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PPD-15

PG 2 OF 2
TDRR NO. 38600

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
FLOAT ASSEMBLY APOLLO II IRIG	2021619		P	R

DESCRIPTION OF CHANGES | **ZONE**

	1	24	2021832-031	Inertia Element & Brg. Assy.
	1	16	2021625-021	Float & Stator Assy.
	AR	11	2021560	Helium High Purity
	AR	10	2021529	Adhesive Epoxy
	1	9	2021528-1	Set Screw Headless
	1	8	2021532-1	Ball Aluminum
	2	7	2021631	Bushing
	1	5	Note 3	Centering Shim
	1	1	2021625-001	Float & Stator Assembly
			2021625-000	Float & Stator Assembly
	-121	Item	Part No.	Description

067

TP 8913

TDRR NO. 38600

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 PI (1-65)

R-30689

PG 1 OF 3
TDRR NO. 37185

TITLE OF DWG/DOC. AGC DSKY OUTLINE DRAWING	CONTRACTOR NO. R-1074	DOC. NO. DASH NO. 2003956	REVISION FROM B	TO C
	MIT ENGINEER E HALL			
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/11/68	TYPE OF DOC 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

NOTES

1. CHANGE NOTE 5 FROM "THE 2.01/1.99 DIMENSION APPLIES TO ALL CONFIGURATION UNIVERSAL DSKYS WITH THE EXCEPTION OF THE 2003985-061, 2003950-031, 2003994-021 & SUBSEQUENT CONFIGURATIONS IN WHICH THE SURFACE OF THE IL & COVER ASSY 2003899-011 SHALL PROTRUDE BEYOND THE MAXIMUM SHOWN UP TO A MAXIMUM OF .09." TO "THE 2.01/1.99 DIMENSION APPLIES TO ALL CONFIGURATION UNIVERSAL DSKYS WITH THE EXCEPTION OF THE 2003985-061, 2003950-031, 2003994-021 & SUBSEQUENT CONFIGURATIONS EXCEPT 2003985-091 IN WHICH THE SURFACE OF THE IL & COVER ASSY 2003899-011 SHALL PROTRUDE BEYOND THE MAXIMUM SHOWN UP TO A MAXIMUM OF .09"

REASON FOR CHANGES

TO CALLOUT 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC CLASS A

REV. CLASS II

OTHER DOCS. AFFECTED: REF PC/SN R1087; 2003994

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A	N/A	

ORGANIZATION AFFECTED: MIT/RAYTHEON

NEXT HIGHER ASSY: N/A

REMARKS:

DOCUMENT NUMBER REPLACED: N/A

INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY M Mileow X
REF E. BOWEN

DESIGN REVIEW APPROVAL MIT/IL
Eldon C Hall 12/20/68
W Stameris 20 Dec 68

MIT CCB APPROVAL
McMurtry 12-24-68 1/10/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
TA Knofsky 10 Jan 69
1/10/69 12/20/68

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ________ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

013

TDRR NO. 37185

REISSUE
12/2/68

PG 1 OF 3

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 PI (1-68)

R30682

TDRR NO. 36656

TITLE OF DWG/DOC.: AGC DSKY ASSEMBLY
CONTRACTOR NO.: R-1014
MIT ENGINEER: E. HALL
DOC. NO. / DASH NO.: 2003994
REVISION FROM: F TO: G
SYSTEM OR SUBSYSTEM: APOLLO, AGC DSKY
DATE ORIGINATED: 7-23-68
TYPE OF DOC.: 01

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 735
CCA 497-0583

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP. CODE 05

DESCRIPTION OF CHANGES

B/M
1. ADD "-041" QTY REQ'D COLUMN WITH QTY'S REQ'D THE SAME AS -031 EXCEPT FIND NO. 4 WHICH IS "1", FIND NO. 20 WHICH IS "12", FIND NO. 21 WHICH IS "24", FIND NO. 22 WHICH IS "70", AND FIND NOS. 27, 30, 31, & 32 WHICH ARE "—", AND FIND NO. 34 WHICH IS "—"

REASON FOR CHANGES: ADDITION OF SAFETY GLASS

DOC. CLASS A
REV. CLASS I

OTHER DOCS. AFFECTED:

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
*		N/A

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: FINAL
REMARKS: *-051 Config. Breakin D-3A & Sub 55
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PAR. S	HIGHER ASSEMBLY	SPARES
NO CHANGE	N/A		N/A
MODIFY			
SCRAP			

PREPARED BY: J. BETTENCOURT
F. RABOIN RAY/ENG
CHK. BY: Murphy
ENGINEERING APPROVAL MIT/IL:
DESIGN REVIEW APPROVAL MIT/IL: Eldon C Hall 24 July 68
W Stameris 23 July 68
CONTRACTOR APPROVAL: 8-1-68
8-5-68
9/23/68
MIT CCB APPROVAL: 8/1/68
NASA APPROVAL:

REISSUE DATE: 12/2/68 REASON:
REISSUE TO CORRECT EFFECTIVITY (SEE TDRR 37079)
CCB INITIAL
MIT-
CONTR-
NASA-

TDRR NO. 36656

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

R1672

PG 1 OF 3
GTDRR NO 37626

TITLE OF DWG/DOC PLATE, MOUNTING	CONTRACTOR NO. KG 2402	DOC. NO DASH NO 1022675	REVISION FROM A	REVISION TO B
	MIT ENGINEER G. Mc WEENEY			
SYSTEM OR SUBSYSTEM GSE-OUA CONTAINER ASSY	DATE ORIGINATED 4-18-69	TYPE OF DOC DRAWING 01		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO 659

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☐ AC [redacted] ☒ KOLLSMAN

DESCRIPTION OF CHANGES
SEE SHEETS 2 & 3

REASON FOR CHANGES
REQUIRED TO RETAIN BELLOWS WHEN MOUNTED ON O.U.A.

DOC. CLASS A
REV. CLASS I

OTHER DOCS. AFFECTED

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
*	*	

ORGANIZATION AFFECTED
KOLLSMAN

NEXT HIGHER ASSY
1022676

REMARKS
*S/N 1 THRU S/N10 MAKE TO THIS CHANGE

DOCUMENT NUMBER REPLACED

INTERFACE AFFECTED

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY L. Barontini
R.B. W

DESIGN REVIEW APPROVAL MIT/IL
W Stameris 23 May 69

MIT CCB APPROVAL
F W Hurley 28 May 69
6/4/69

ENGINEERING APPROVAL MIT/IL
Ed

CONTRACTOR APPROVAL
D J Beker 6/3/69

NASA APPROVAL

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

G TDRR NO. 37626

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 1 OF 3
TDRR NO. 38515

TITLE OF DWG/DOC. FIRST TIME TURN-ON OF INERTIAL SUBSYSTEM (ISS) POWER	CONTRACTOR NO. A 19083	DOC. NO. JDC 14033	REVISION FROM N	REVISION TO P
	MIT ENGINEER			
SYSTEM OR SUBSYSTEM ISS	DATE ORIGINATED 10-11-71	TYPE OF DOC. JDC 09		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ ECP NO. 1025 R1

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC ☐ KOLLSMAN

DESCRIPTION OF CHANGES

1. Change Step A.1 from ". . . until the G/N Power A bus indicator is lighted." to ". . . until the G/N Power B bus indicator is lighted."
2. Change Step A.4 from "G/N Power A bus" to "G/N Power B bus."
3. Change Step A.14 from "G/N Power A bus" to "G/N Power B bus."
4. Add the following steps after Step A.25:

   25.a Press the 0IA ON pushbutton.

REASON FOR CHANGES 1, 2, 3 and 4 -- Adds check of G/N B buss inputs.
5. Verifies PTC interlock signal.
6. Verifies Heater and Blower Telemetry discretes.
7, 8. Verifies servo amp input test points.

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: N/A

EFFECTIVITY		
HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A	N/A	N/A

ORGANIZATION AFFECTED
NEXT HIGHER ASSY: ATP 2015497, ND1021043
REMARKS: ~~*No retest required~~
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: None

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	X	X	X
MODIFY			
SCRAP			

PREPARED BY: P. Headley
DESIGN REVIEW APPROVAL MIT/IL: W Stameris 8 Nov 71
~~MIT~~ CCB APPROVAL: 12/6/71
ENGINEERING APPROVAL ~~MIT/IL~~: 11/5/71
CONTRACTOR APPROVAL: 11/24/71
NASA APPROVAL
REISSUE DATE: ______ REASON:
12-3-71
CCB INITIAL
MIT-
CONTR-
NASA-

TP8913

W A 984208

TDRR NO. 38515

PG 2 OF 3

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P2 (1-65)

E-30689

TDRR NO. 37185

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
AGC DSKY OUTLINE DRAWING	2003956		B	C

DESCRIPTION OF CHANGES

ZONE

NOTES CONT'd

2. CHANGE NOTE 6 FROM "THE 2003985-061, 2003950-031, 2003994-021 & SUBSEQUENT CONFIGURATIONS SHALL REFLECT "PRO" IN KEY POSITION INDICATED". TO "THE 2003985-061, 2003950-031, 2003994-021 & SUBEQUENT CONFIGURATIONS SHALL REFLECT "PRO" IN KEY POSITION INDICATED, EXCEPT 2003985-091"

FOR ADDITIONAL CHANGES SEE PAGE 3 OF THIS TDRR
(PAGE 3 IS A MARKED SEPIA)

TP 8913

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION
FORM 53-4026 P2 (1-66)

PG 2 OF 3
TDRR NO. 36656

R30682

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
AGC DSKY ASSEMBLY	2003994		F	G

DESCRIPTION OF CHANGES | ZONE

2. ADD "-051" QTY REQ'D COLUMN WITH QTY'S REQ'D THE SAME AS -041 EXCEPT FIND NO. 4 WHICH IS "-", FIND NO. 22 WHICH IS "66", AND FIND NO. 27 WHICH IS "1"
3. ADD FIND NO. 35 "(12:12:-:-:-); 2004932-004; SCREW, JACKING"
4. ADD FIND NO. 36 "(2:2:-:-:-); 2003897-041; COVER ASSY"

NOTE APPLICATION TABLE

5. ADD THE FOLLOWING:

"

-051	1 THRU 13, 15, 18
-041	1 THRU 13, 15, 18

"

NOTES

6. CHANGE NOTE 3 FROM "MOUNTING --- NO. 19 AND JACK ----- POUNDS." TO "MOUNTING --- NO. 19, 35 AND JACK ----- POUNDS."
7. CHANGE NOTE 15 FROM "THE -011 CONFIGURATION ---- -021 & -031 CONFIGURATION --- INDICATED." TO "THE -011 & -041 CONFIGURATION ---- -021, -031, & -051 CONFIGURATION --- INDICATED."
8. CHANGE NOTE 18 FROM "PRIOR TO ---- FIND NO. 27 WITH FIND NO. 33." TO "PRIOR TO ---- FIND NO. 27 OR FIND NO. 4 WITH FIND NO. 33."

FOR ADDITIONAL CHANGES SEE PAGE 3 OF THIS TDRR

TP 8913

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

PG 2 OF 3
G TDRR NO. 37626

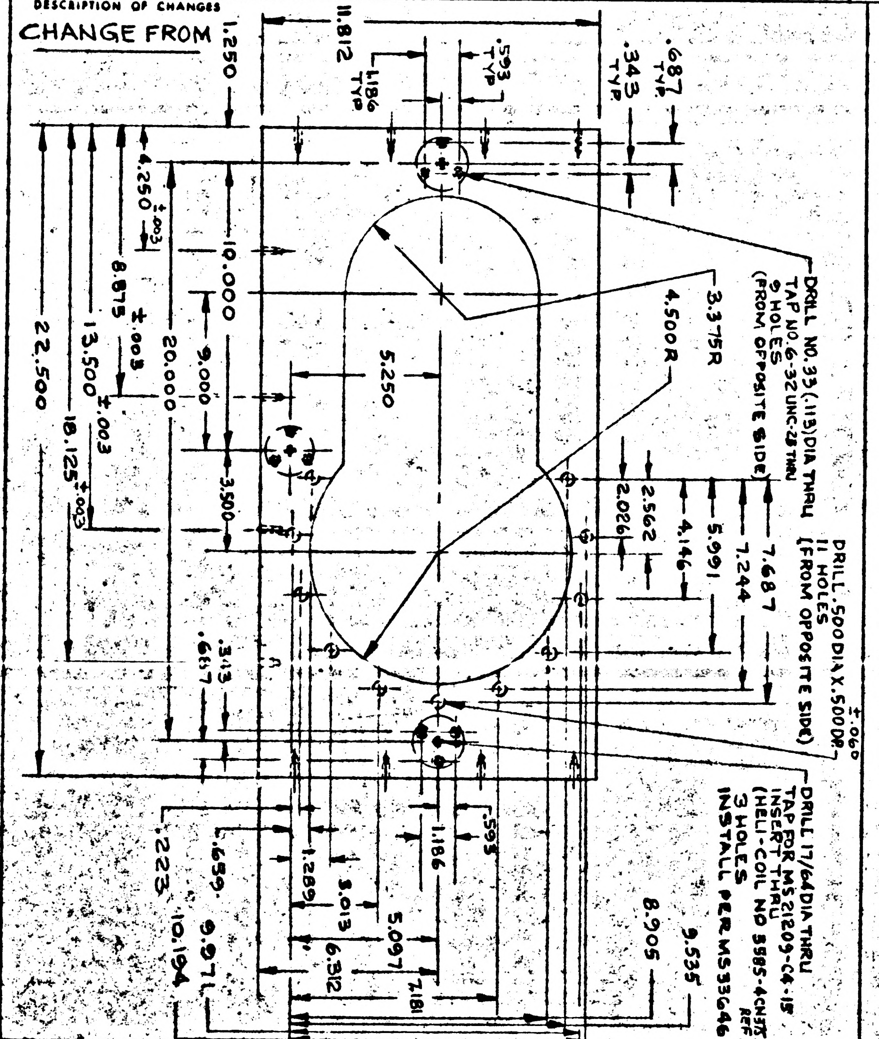
KG 2402

TITLE OF DWG/DOC.	DOC. NO.	DASH NO.	REVISION FROM	REVISION TO
PLATE, MOUNTING	1022675		A	B

DESCRIPTION OF CHANGES

ZONE

CHANGE FROM



11.812
1.250
.593 TYP
1.186 TYP
.343 TYP
.687 TYP
4.250 ±.003
10.000
8.875 ±.003
9.000
20.000
13.500 ±.003
18.125 ±.003
22.500
5.250
3.500
3.375R
4.500R
DRILL NO.33 (.113) DIA THRU TAP NO.6-32UNC-2B THRU 9 HOLES (FROM OPPOSITE SIDE)
2.026
2.562
4.146
5.991
7.244
7.687
DRILL .500 DIA X .500 DP ±.060 11 HOLES (FROM OPPOSITE SIDE)
.313
.617
.223
.659
1.289
3.013
5.097
6.312
7.181
1.186
.593
9.971
10.194
8.905
9.535
DRILL 17/64 DIA THRU TAP FOR MS21209-C4-15 INSERT THRU (HELI-COIL NO 3585-4CN375 REF) 3 HOLES INSTALL PER MS33646

G TDRR NO. 37626

TITLE OF DWG/DOC.	DOC NO.	REVISION FROM	REVISION TO
FIRST TIME TURN-ON OF INERTIAL SUBSYSTEM (ISS) POWER	JDC 14033	N	P

DESCRIPTION OF CHANGES — **ZONE**

25.b Press the G/N Power A bus/G/N Power B bus pushbutton until the G/N Power A bus indicator is lighted.

25.c Press the ISS standby pushbutton.

25.d Observe the temperature monitor control panel and insure that the PSA heater power lamp is lighted.

5. Add step 2a as follows:

2.a Monitor the PTC interlock signal on the DVM by setting the CROSSBAR CONTROL to 100. Insure that this discrete changes from OFF to ON (0±5 VDC to 28.3±3 VDC) when the IMU Standby Power is applied in Step A3.

6. Add the following steps after Step A.35:

35.a Monitor the Blower Telemetry Discrete on the DVM by setting the CROSSBAR CONTROL to 199 and connecting the Buffered Probes on TPA 2 to TB 4-20 high and TB 5-33 low. Insure that this discrete is not present (0 ± 5 V RMS).

35.b Monitor the Heater Telemetry Discrete on the DVM by setting the CROSSBAR CONTROL to 299 and connecting the Direct Probes on TPA 2 to TB 4-21 high and TB 5-22 low. Insure that this discrete is cycling on and off (28 ± 3 VDC and 0 ± 5 VDC).

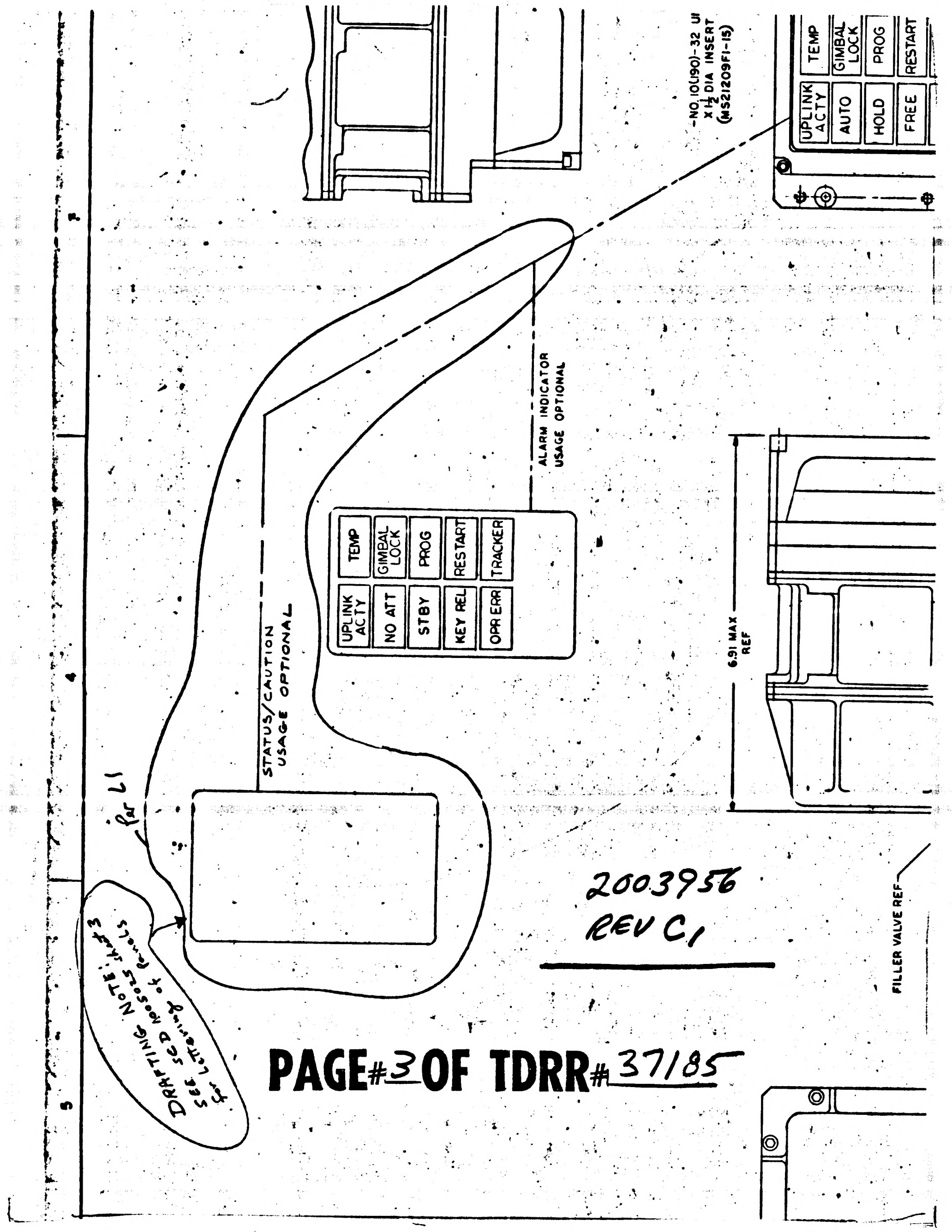
35.c Repeat Step A.27.

7. Add the following after Step 61. Renumber present Step 62 to 65.

62. Monitor and record the in-phase component of the IG Servo Error by setting the CROSSBAR CONTROL to 199 and connecting the buffered probes on TPA #2 to TB5-32 high and TB 5-40 low.

63. Monitor and record the in-phase component of the MG Servo Error by setting the CROSSBAR CONTROL to 199 and connecting the buffered probes on TPA #2 to TB 5-41 high and TB 5-40 low.

TP 8913


-NO. 10(U90)-32 UI
X 1½ DIA INSERT
(MS21209F1-15)
UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
ALARM INDICATOR
USAGE OPTIONAL
UPLINK ACTY
TEMP
NO ATT
GIMBAL LOCK
STBY
PROG
KEY REL
RESTART
OPR ERR
TRACKER
STATUS/CAUTION
USAGE OPTIONAL
6.91 MAX
REF
FILLER VALVE REF
4
5
Par L1
DRAFTING NOTE: sheet 3
SEE SCD N00s0 Panels
for Lettering of

2003956
REV C1

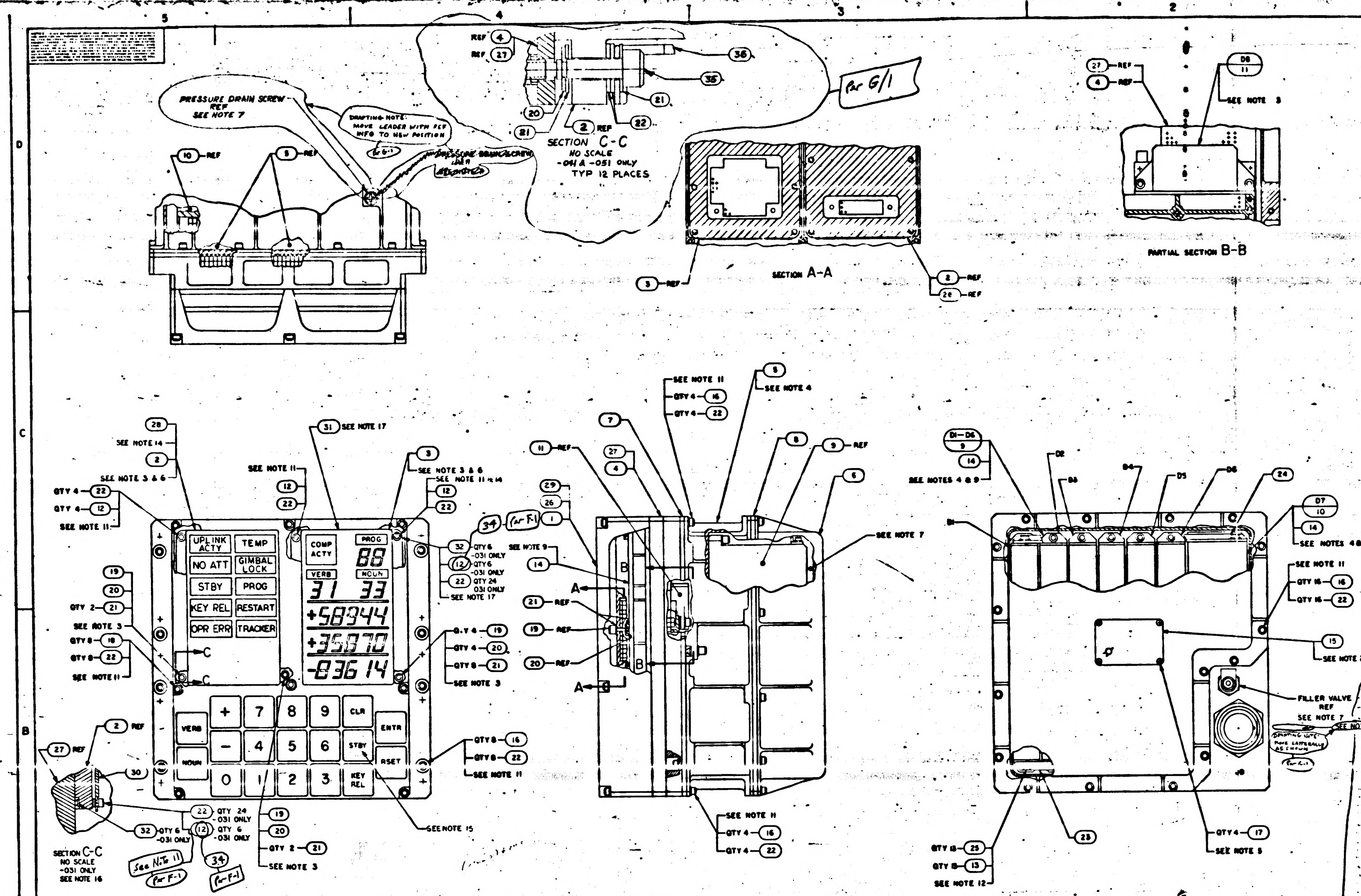
PAGE#3 OF TDRR#37/85

2003994 E
F/1
G1

SYM	DESCRIPTION	DATE	APPROVAL
A	INITIAL RELEASE [illegible]	[illegible]	[illegible]
B	CHANGED PER TDRR 33445 DR [illegible] CHK [illegible]	[illegible]	[illegible]
C	REVISED PER TDRR 35065 DR [illegible] CHK [illegible]	[illegible]	[illegible]
D	REVISED PER TDRR 3_256 DR [illegible] CHK [illegible]	[illegible]	[illegible]
E	REVISED PER TDRR 36459 DR [illegible] CHK [illegible]	[illegible]	[illegible]

F·1 REV PER CCA R-30677 TDRR ____
ENG [illegible] CHK ____

G1 REV PER CCA R-30683 TDRR ____
ENG [illegible] 7/26/70 CHK [illegible]


REF
4
27
36
35
21
22
20
81
2 REF
SECTION C-C
NO SCALE
-041 & -051 ONLY
TYP 12 PLACES
Par G/1
PRESSURE DRAIN SCREW
REF
SEE NOTE 7
DRAFTING NOTE
MOVE LEADER WITH FIX
INFO TO NEW POSITION
PRESSURE DRAIN SCREW
REF
10 REF
8 REF
3 REF
SECTION A-A
2 REF
28 REF
27 REF
4 REF
D8
11
SEE NOTE 3
PARTIAL SECTION B-B
28
SEE NOTE 14
2
SEE NOTE 3 & 6
QTY 4 22
QTY 4 12
SEE NOTE 11
31 SEE NOTE 17
SEE NOTE 11
12
22
3
SEE NOTE 3 & 6
SEE NOTE 11 & 14
12
22
32 QTY 6 -031 ONLY
12 QTY 6 -031 ONLY
22 QTY 24 -031 ONLY
SEE NOTE 17
34
Par F-1
UPLINK ACTY
TEMP
NO ATT
GIMBAL LOCK
STBY
PROG
KEY REL
RESTART
OPR ERR
TRACKER
COMP ACTY
PROG
88
VERB
NOUN
+58344
+35070
-03614
VERB
NOUN
+
-
0
7
8
9
4
5
6
1
2
3
CLR
ENTR
STBY
RSET
KEY REL
19
20
QTY 2 21
SEE NOTE 3
QTY 8 19
QTY 8 22
SEE NOTE 11
QTY 4 19
QTY 4 21
QTY 8 20
SEE NOTE 3
QTY 8 16
QTY 8 22
SEE NOTE 11
2 REF
27 REF
30
22 QTY 24 -031 ONLY
32 QTY 6 -031 ONLY
12 QTY 6 -031 ONLY
19
20
QTY 2 21
SEE NOTE 3
SEE NOTE 15
SECTION C-C
NO SCALE
-031 ONLY
SEE NOTE 16
See Note 11
Par F-1
34
Par F-1
SEE NOTE 11
QTY 4 16
QTY 4 22
5
SEE NOTE 4
7
27
4
11 REF
8
9 REF
6
29
26
1
SEE NOTE 9
14
SEE NOTE 7
21 REF
19 REF
20 REF
A
B
C
SEE NOTE 11
QTY 4 16
QTY 4 22
D1-D6
9
14
SEE NOTES 4 & 9
D2
D3
D4
D5
D6
24
D7
10
SEE NOTES 4 & 9
SEE NOTE 11
QTY 16 16
QTY 16 22
15
SEE NOTE 2
FILLER VALVE
REF
SEE NOTE 7
SEE NOTE 18
23
QTY 13 25
QTY 13 13
SEE NOTE 12
QTY 4 17
SEE NOTE 5

PAGE#3OF TDRR#36656
of 2

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	FIND NO
2	2	—	—	—	2003897-041	COVER ASSY	36
12	12	—	—	—	2004932-004	SCREW, JACKING	35
—	—	12	—	—	1001489-26	SCREW, HEX, SOCKET HEAD	34
—	AR	AR	—	—	MIL-S-[illegible]	SILICONE COMPOUND	33
—	—	12	—	—	MS24775-[illegible]	O RING	32
—	—	1	—	—	2003897-031	E/L COVER ASSY	31
☒	☒	☒	☒	☒	2003956	OUTLINE DRAWING	REF
☒	☒	☒	☒	☒	2005957	SIGNAL PIN ASSIGNMENT	REF
☒	☒	☒	☒	☒	[illegible]	INTERCONNECTING DIAGRAM	REF
☒	☒	☒	☒	☒	2005918	SIGNAL FLOW DIAGRAM	REF
—	—	1	—	—	2003897-021	I/L COVER ASSY	30
1	1	1	—	—	2004739-001	COVER FRONT	29
—	—	—	1	—	[illegible]	INDICATOR ALARM & COVER ASSY	28
1	—	1	1	—	[illegible]	FRONT HOUSING ASSY	27
—	—	—	1	—	[illegible]	COVER FRONT	26
13	13	13	13	13	NAS620C4	WASHER, FLAT	25
1	1	1	1	1	2004958	BRACKET, MODULE	24
1	1	1	1	1	2004959	BRACKET, MODULE	23
66	70	56	42	46	NAS620C6	WASHER, FLAT	22
24	24	-	9	12	1004546-4	WASHER, FLAT	21
12	12	-	4	6	MS16633-4014	RING, RETAINING	20
—	—	—	4	6	2004932-001	SCREW, JACKING	19
8	8	8	8	8	1001489-59	SCREW, HEX SOCKET HEAD	18
4	4	4	4	4	MS35216-1	SCREW, PAN HEAD, CROSS RECESSED	17
32	32	32	32	32	MS16995-18	SCREW, HEX, SOCKET HEAD	16
1	1	1	1	1	1004260-20	NAMEPLATE	15
AR	AR	AR	AR	AR	1006879	SILICONE COMPOUND	14
13	13	13	13	13	MS16995-10	SCREW, HEX SOCKET HEAD	13
—	—	[illegible]	2	6	MS16995-20	SCREW, HEX, SOCKET HEAD	12
1	1	1	1	1	2003909-031	KEYBOARD MODULE ASSY D8	11
1	1	1	1	1	2003901-031	POWER SUPPLY ASSY MODULE D7	10
6	6	6	6	6	2003952-031	INDICATOR DRIVER MODULE D1-D6	9
1	1	1	1	1	1006349	GASKET, BONDED, RUBBER	8
1	1	1	1	1	1006350	GASKET, BONDED, RUBBER	7
1	1	1	1	1	2004900	COVER, REAR	6
1	1	1	1	1	2003685-011	MAIN HOUSING ASSY	5
—	1	—	—	1	2003949-021	FRONT HOUSING ASSY	4
1	1	1	1	1	1006315-001	INDICATOR, DIGITAL	3
1	1	1	—	1	SEE NOTE 13	INDICATOR, ALARM	2
—	—	—	—	1	2004929-021	COVER, FRONT	1
051	041	031	021	011	LIST OF MATERIALS		

3
Par F-1
Par G-1

NOTES

1. INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327
2. MARK AGC DSKY ASSEMBLY AND ITS RESPECTIVE PART NO., SERIAL NO., AND CONTRACT NO. MARKING TO BE PER ND1002019 AND SERIALIZE PER ND1002023
3. MOUNTING TORQUE FOR FIND NO. 19 ~~AND JACK~~ SCREWS OF FIND NO. 11 & 28 TO BE 8.5-9.5 INCH POUNDS
4. MOUNTING TORQUE FOR JACK SCREWS OF FIND NO. 5, 9 & 10 TO BE 15-19 INCH POUNDS
5. APPLY SEALING COMPOUND MIL-S-22473 GRADE HV TO FIND NO. 17
6. FIND NO. 2 AND 3 TO BE ASSEMBLED TO HEIGHT OF BONDED RUBBER OF FIND NO. 4 USING FIND NO. 19. BEFORE INSTALLING FIND NO. 12, ASSEMBLE IN AN ENVIRONMENT HAVING A TEMPERATURE OF 72° ±5° AND A RELATIVE HUMIDITY OF 50% OR LESS
7. FILL WITH A MINIMUM OF 87% NITROGEN AND 8.7% HELIUM AND A MAXIMUM OF 4.3% AIR TO 1.05/1.10 ATMOSPHERES. DO NOT EXCEED 2 ATMOSPHERES DURING PRESSURIZATION
8. COMPLETED ASSEMBLY SHALL BE TESTED IN ACCORDANCE WITH AND SHALL MEET ALL THE REQUIREMENTS OF PS2016030 OR PS2016031.
9. APPLY FIND NO. 14 TO INTERFACE SURFACES OF THE FOLLOWING FIND NO'S: 4 OR 27 & 2 OR 28, 4 OR 27 & 3, 5 & 9, AND 5 & 10 DO NOT APPLY FIND NO. 14 TO BONDED RUBBER SURFACES, TAPPED HOLES, OR MOUNTING HARDWARE.
10. AR DENOTES AS REQUIRED
11. MOUNTING TORQUE FOR FIND NO. 16, 18, AND 12 TO BE 8-9 INCH POUNDS 12 34 Par F-1
12. MOUNTING TORQUE FOR FIND NO. 13 TO BE 3.5-4.5 INCH POUNDS
13. FIND NO. 2 TO BE EITHER 1005387-002 OR 1006387-003
14. FIND NO. 3 TO BE ASSEMBLED TO HEIGHT OF BONDED RUBBER OF FIND NO. 27 USING FIND NO. 19 BEFORE INSTALLING FIND NO. 12. FIND NO. 28 TO BE ASSEMBLED USING EXISTING JACKING SCREWS. ASSEMBLE IN AN ENVIRONMENT HAVING A TEMPERATURE OF 72° ±5°F AND A RELATIVE HUMIDITY OF 50% OR LESS
15. THE -041 CONFIGURATION SHALL REFLECT A NOMENCLATURE AS SHOWN THE -021 & -031 -051 CONFIGURATION SHALL REFLECT "PRO" IN KEY POSITION INDICATED. Par G-1 Par G1
16. ASSEMBLE FIND NO. 30 TO FIND NO. 2 USING FIND NO. 12 34 Par F-1 USE FIND NO. 22 QTY 3 PER SCREW AS SHIMS, BETWEEN FIND NO. 30 AND FIND NO. 2. USE FIND NO. 22 QTY 1 PER SCREW UNDER EACH SCREW HEAD. USE FIND NO. 32 QTY 1 PER SCREW ON THE THREADED PORTION OF EACH SCREW TO ACT AS A RETAINING RING DURING ASSEMBLY OF FRAME & LIGHT ONTO THE DSKY. CAUTION SHOULD BE EXERCISED PRIOR TO ASSEMBLY TO DSKY AS IT IS DIFFICULT TO REMOVE FIND NO. 2 AFTER ASSEMBLY WITHOUT JACKING HARDWARE

REF. DWGS

1.	UNIVERSAL DSKY SHIPPING CONTAINER	1006422
2.	DSKY CONNECTOR COVER	1006425-14
3.	UNIVERSAL DSKY HANDLING FIXTURE	2014013

NOTES:

17. ASSEMBLE FIND NO. 31 TO FIND NO. 3 USING FIND NO. 12 34 Par F-1 USE FIND NO 22, QTY 3 PER SCREW AS SHIMS BETWEEN FIND NO 31 AND FIND NO 3. USE FIND NO. 22, QTY 1 PER SCREW UNDER EACH SCREW HEAD, USE FIND NO. 32 ON THE THREADED PORTION OF EACH SCREW TO ACT AS A RETAINING RING DURING ASSEMBLY OF FRAME & LIGHT ONTO DSKY. CAUTION SHOULD BE EXERCISED PRIOR TO ASSEMBLY TO DSKY AS IT IS EXTREMELY DIFFICULT TO REMOVE FIND NO. 3 AFTER ASSEMBLY WITHOUT JACKING HARDWARE. OR FIND No 4 Par G-1
18. PRIOR TO ASSEMBLY OF FIND NO. 2 AND FIND NO. 3 TO FIND NO. 27 FILL FEMALE INSULATORS OF FIND NO 27 WITH FIND NO. 33

-051	1 THRU 13, 15, 18
-041	1 THRU 13, 15, 18
-031	1 THRU 5,7,9,10,11,12,13,15,16,17,18
-021	1 THRU 5, 7 THRU 12, 14 & 15
-011	1 THRU 13 & 15
DASH NO.	APPLICABLE NOTES

NOTE APPLICATION

Par G1

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
DO NOT SCALE THIS DRAWING
MATERIAL
HEAT TREATMENT
FINAL FINISH

M I T
INSTRUMENTATION LAB
CAMBRIDGE MASS
DRAWN [illegible] DATE [illegible]
CHECKED [illegible]
APPROVAL
APPROVAL [illegible]
NASA APPROVAL
NASA APPROVAL

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

AGC DSKY ASSEMBLY

CODE IDENT NO 80230
SIZE J
NASA DRAWING NO 2003994
SCALE 1/1
WT
SHEET 1 OF 1

2003994 E F·1 G1

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

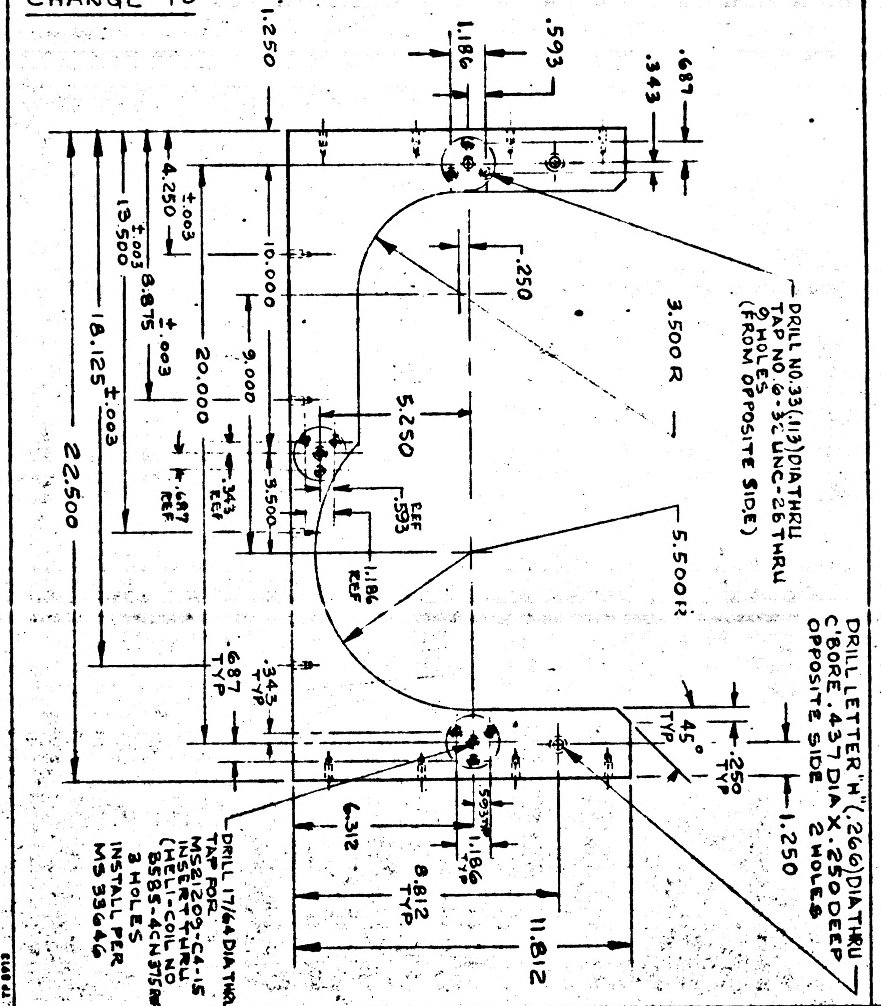
KG 2402

PG 3 OF 3
GTDRR NO. 37626

TITLE OF DWG/DOC.	DOC NO.	DASH NO.	REVISION FROM	REVISION TO
PLATE, MOUNTING	1022675		A	B

DESCRIPTION OF CHANGES

CHANGE TO



1.250
1.186
.593
.687
.343
4.250 ±.003
13.500 ±.003
8.875 ±.003
10.000
20.000
9.000
18.125 ±.003
22.500
.250
3.500 R
5.250
3.500
.343 REF
.687 REF
.593 REF
1.186 REF
5.500 R
DRILL NO.33(.113)DIA THRU TAP NO 6-32 UNC-2B THRU 9 HOLES (FROM OPPOSITE SIDE)
.343 TYP
.687 TYP
45° TYP
.250 TYP
1.250
DRILL LETTER 'H' (.266) DIA THRU C'BORE .437 DIA X .250 DEEP OPPOSITE SIDE 2 HOLES
6.312
8.812 TYP
11.812
.593 TYP
1.186 TYP
DRILL 17/64 DIA THRU TAP FOR MS21209-C4-15 INSERT-THRU (HELI-COIL NO 3585-4CN375 REF) 3 HOLES INSTALL PER MS 33646

ZONE

GTDRR NO 37626

TITLE OF DWG/DOC.	DOC. NO.	REVISION FROM	REVISION TO
FIRST TIME TURN-ON OF INERTIAL SUBSYSTEM (ISS) POWER	JDC 14033	N	P

DESCRIPTION OF CHANGES **ZONE**

64. Monitor and record the in-phase component of the OG Servo Error by setting the CROSSBAR CONTROL to 199 and connecting the buffered probes on TPA #2 to TB 5-31 high and TB 5-40 low.

8. Add the following to the data sheet:

A. 62	IG Servo Error	mv			60		
A. 63	MG Servo Error	mv			60		
A. 64	OG Servo Error	mv			60		

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION REISSUE

PG 1 OF 4
TDRR NO. 26044

TITLE OF DWG/DOC. GIMBAL SERVO AMPLIFIER ASS'Y	CONTRACTOR NO. A11590 E	DOC. NO. DASH NO.	REVISION FROM	TO
	MIT ENGINEER G. Ives	2007114 ~~[illegible]~~	~~J~~ #	~~K~~ ↓
SYSTEM OR SUBSYSTEM PSA	DATE ORIGINATED 12-27-65	TYPE OF DOC. Drawing		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☐ NECP NO. ______

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☒ AC SPARK ☐ HOLLSMAN

DESCRIPTION OF CHANGES

1. In Parts List Change the P/N of:

Find No.	From	To
29	1006750-60	1006750-84
33	1006750-70	1006750-67
59	1010372-15	1010372-13

2. In Parts List change the quantity of:
Find No.: 27 from: 2 To: 1 (Resistor, 1006750-51)

3. In Parts List delete Find No. 42, 1010369-85, Resistor.

REASON FOR CHANGES

To improve ease of module testing. This change reduces the temperature sensitivity of the input DC offset from 1.0 millivolts RMS per deg. C to approximately 0.1 millivolts RMS/°C. Temperature gradients produced by the power transistors make testing difficult.

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED
2010004 SCHEMATIC

EFFECTIVITY

HARDWARE CUT-IN	HARDWARE CUT-OUT	SPARES
N/A		

ORGANIZATION AFFECTED
AC Electronics Div.

NEXT HIGHER ASSY
2007200, 6007200

REMARKS:

DOCUMENT NUMBER REPLACED

INTERFACE AFFECTED

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE		X	X
MODIFY	X		
SCRAP			

PREPARED BY H Miller
R. Kraemer

DESIGN REVIEW APPROVAL MIT/IL
John E Miller 2/4/66

MIT CCB APPROVAL
W Kupfer 9 Feb 66

ENGINEERING APPROVAL MIT/IL
G Ives 2-7-66

CONTRACTOR APPROVAL
2/9/66

NASA APPROVAL
NOT REQUIRED PER LETTER
NASA PP7-65-612

REISSUE DATE: 12-28-66 REASON:
*To make applicable to all configurations
REVISE SHEET 1 ONLY

CCB INITIALS
MIT-
CONTR-
NASA-

TP8013

TDRR NO. 26044

362

PG 1 OF 4

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

TDRR NO. 37173

TITLE OF DWG/DOC.: Multiple Initial Release
CONTRACTOR NO.:
MIT ENGINEER:
DOC. NO. / DASH NO: See Below
REVISION FROM: - TO: -
SYSTEM OR SUBSYSTEM: Apollo Rangefinder
DATE ORIGINATED: 1-6-69
TYPE OF DOC.: Drawings 01

☒ INITIAL RELEASE
☐ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☐ TDRR ONLY
☒ TDRR & DOCUMENT
☒ ~~M~~ ECP NO. CCA497-0605 ECP 764

MASTER DOCUMENT LOCATION
☐ MIT/IL ☐ RAYTHEON
☐ AC SPARK ☒ KOLLSMAN

DESCRIPTION OF CHANGES

ALL REV —

Part No.	Title
✓2013250	Apollo Rangefinder
✓2013350	Diastimeter Assy
✓2013275	Telescope Assy
✓2013289	Strap Assy
✓2013291	Slide
✓2013292	Bracket, Strap
✓2013400	Eyepiece Assy
✓2013297	Battery Encapsulation Assy
✓2013298	Battery (SCD)
✓2013254	Plate & Bracket Assy
✓2013253	Plate, Bracket
✓2013252	Dovetail (Optical Rangefinder)
~~2013319-003~~	~~Pin, Bezel~~

EQUIP CODE 65

REASON FOR CHANGES: INITIAL RELEASE

DOC. CLASS: A
REV. CLASS: N/A

OTHER DOCS. AFFECTED:

EFFECTIVITY		
HARDWARE		SPARES
CUT-IN	CUT-OUT	
N/A		

ORGANIZATION AFFECTED: KOLLSMAN
NEXT HIGHER ASSY: N/A
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE	N/A		
MODIFY			
SCRAP			

PREPARED BY: 1-6-69
DESIGN REVIEW APPROVAL MIT/IL: 1-8-69
~~MIT~~ CCB APPROVAL: DAH
ENGINEERING APPROVAL MIT/IL:
CONTRACTOR APPROVAL:
NASA APPROVAL: JUN 1/8/69 APPROVED CCA497-0273

REISSUE DATE:________ REASON:

CCB INITIAL
MIT–
CONTR–
NASA–

014

TDRR NO. 37173

PG 2 OF 4

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

2 TDRR NO. 37173

3 SYSTEM OR SUBSYSTEM Apollo Rangefinder	5 CONTRACTOR NO.	6 DOC. NO. DASH NO. See Below	REVISION FROM – TO –
4 TITLE OF DWG / DOC. Multiple Initial Release	MIT ENGINEER		
	DATE ORIGINATED 1-6-69	7 TYPE OF DOC. Drawings	

8 DESCRIPTION OF CHANGES

Part No.	Title	ZONE
0 ✓2013251	Plate, Identification	
✓2013339	Cover, Battery Assy	
✓2013311	Cover, Battery	
✓2013325	Washer, Wave	
[redacted]	[redacted]	
✓2013276	Housing, Telescope	
✓2013277	Support, Mirrors Fixed Assy of	
✓2013278	Support, Mirrors, Fixed	
✓2013279	Mirror, Fixed	
✓2013281	Washer, Wave	
✓2013280	Bushing, Mirror	
[redacted]	[redacted]	
✓2013319 [redacted]	Pin, Dowel	
✓2013283	Lens, Objective, Assy of	
✓2013284	Housing, Lens, Objective	
✓2013285	Lens, Negative, Objective	
✓2013286	Spacer, Lens, Objective	
✓2013287	Lens, Positive, Objective	
✓2013288	Ring, Locking, Objective Lens	
✓2013318	Ring, Locking, Objective Lens	
✓2013323	Bushing, Threaded	
✓2013321	Bushing, Insulator	
✓2013397	Plate, Insulator	
✓2013322	Insulator, Electrical	
✓2013324	Spring, Contact	
✓2013326	Screw, Pan Hd	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
✓2013300	Strap, Prism	
✓2013299	Prism	
✓2013305	Insulator, Electrical	
✓2013302	Block, Alignment	
✓2013337 [redacted]	Screw, Cap, Soc Hd	
✓2013303	Reticle	
✓2013304	Retainer, Reticle	
✓2013306	Flange, Mounting, Eyepiece	
✓2013293	Latch, Assy of	
✓2013294	Latch	
✓2013320	Pin, Headed	
✓2013307	Screw, Shoulder	
[redacted]	[redacted]	
✓2013308	Spacer	
✓2013310	Spring, Torsion	
✓2013313	Cover, Rear (Porro Prism)	
✓2013452	Mount, Diastimeter	
✓2013301	Spacer	
~~[illegible]~~	~~Diastimeter, Assy~~	
✓2013375	Spur Gear & Wedge Assy	

2 TDRR NO. 37173

PG 3 OF 4

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

2 TDRR NO. 37173

3 SYSTEM OR SUBSYSTEM Apollo Rangefinder	5 CONTRACTOR NO.	6 DOC. NO. DASH NO. See Below	REVISION FROM - TO -
4 TITLE OF DWG / DOC. Multiple Initial Release	MIT ENGINEER		
	DATE ORIGINATED 1-6-69	7 TYPE OF DOC. Drawings	

8 DESCRIPTION OF CHANGES — ZONE

Part No.	Title
✓2013376	Gear, Spur (198T/96P)
✓2013398	Spacer
✓2013377	Wedge Assy
✓2013380	Gear, Spur (198T/96P)
~~2013377~~	~~Wedge Assy~~
✓2013357	Knob & Pin Assy
✓2013358	Knob, Dial
~~2013319-001~~	~~Dowel Pin~~
✓2013460	Bracket & Mirror Assy
✓2013455	Bracket, Mirror
✓2013454	Mirror
✓2013370	Housing, Bevel Gear, Pin Assy
✓2013373	Housing, Gear
✓2013363	Limit Stop
~~2013319-001~~	~~Pin, Dowel~~
✓2013381	Housing & Gear Plate Assy (Mach)
✓2013384	Housing, Beamsplitter & Gear
✓2013382	Gear Plate
~~2013337-003~~	~~Screw Cap, Soc Hd~~
✓2013395	Gear 25T/96P
✓2013368	Terminal Board Assy
✓2013369	Board Terminal
✓2013394	Gear, Spur 51T,96P
✓2013391	Gear, Spur 33T,96P
[illegible]	[illegible]
✓2013354	Washer, Flat
✓2013392	Gear 95T/96P
✓2013393	Gear 43T/96P
✓2013385	Drum
✓2013362	Ring, Locking
✓2013371	Shaft
✓2013361	Adapter, Limit Stop
✓2013365	Limit Stop
✓2013364	Limit Stop
✓2013372	Gear, Bevel 46T/96P
✓2013355	Bushing, Mirror
[illegible]	[illegible]
✓2013352	Mirror, Fixed
✓2013399	Ring, Threaded
✓2013356	Window
✓2013353	Mirror, Housing
✓2013390	Ring, Bearing
✓2013388	Beamsplitter
✓2013387	Bezel
✓2013386	Magnifier Lens
✓2013456	Window
✓2013459	Spacer
✓2013450	Cover, Dust

✓

2 TDRR NO. 37173

PG 4 OF 4

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION

2 TDRR NO. 37173

3 SYSTEM OR SUBSYSTEM Apollo Rangefinder	5 CONTRACTOR NO.	6 DOC. NO. DASH NO. See Below	REVISION FROM -	TO -
4 TITLE OF DWG / DOC. Multiple Initial Release	MIT ENGINEER			
	DATE ORIGINATED 1-6-69	7 TYPE OF DOC. Drawings		

8 DESCRIPTION OF CHANGES

Part No.	Title	ZONE
✓2013453	Spacer	
✓2013359	Pin, Plain Tappered	
✓2013451	Washer, Wave	
✓2013389	Washer, Wave	
✓2013255	Wiring Diagram	
✓~~[illegible]~~	~~Eyepiece Assy~~	
✓2013402	Lens Assy, Triplet	
✓2013403	Lens Convex & Plano	
✓2013404	Lens Negative	
✓2013405	Lens Positive	
✓2013424	Screw Set. Hex. Soc. Hd Cup PT	
✓2013423	Shoe	
✓2013401	Housing Lens	
✓2013415	Spacer Lens	
✓2013416	Lens Positive	
✓2013417	Spacer Lens	
✓2013418	Nut Lens Locking	
✓2013419	Shim Eyeguard	
✓2013420	Nut Eyeguard Retainer	
✓2013421	Guard Eyepiece	
✓2013422	Ring Engraved	
✓2013406	Lens Assy, Doublet	
✓2013407	Lens Negative	
✓2013408	Lens Positive	
✓2013409	Eyeguard Assy	
✓2013410	Holder Eyeguard	
✓2013411	Eyeguard	
✓2013412	Support Eyepiece Assy	
✓2013413	Support Eyepiece	
✓2013336	Pin, Dowel	
✓2013425	NUT, EYEGUARD RETAINER	

2 TDRR NO. 37173

PG 1 OF 7

APOLLO GUIDANCE AND NAVIGATION
TECHNICAL DATA RELEASE OR REVISION R-30689
FORM 53-4026 P1 (1-65)

TDRR NO. 37183

TITLE OF DWG/DOC. DSKY TEST DATA	CONTRACTOR NO. R-1087	DOC. NO. DASH NO. JDC 05393	REVISION FROM B	TO C
	MIT ENGINEER E. HALL			
SYSTEM OR SUBSYSTEM AGC BL II	DATE ORIGINATED 12/18/68	TYPE OF DOC. 09		

☐ INITIAL RELEASE
☒ REVISION
☐ NON-INTERCHANGEABLE REPLACEMENT

☒ TDRR ONLY
☐ TDRR & DOCUMENT
☒ NECP NO. 739

MASTER DOCUMENT LOCATION
☐ MIT/IL ☒ RAYTHEON
☐ AC SPARK ☐ KOLLSMAN

EQUIP CODE 05

DESCRIPTION OF CHANGES

1. ADD REV 'C' TO REV LTR COL

FOR CHANGES SEE PAGES 2 THRU 7 OF THIS TDRR

REASON FOR CHANGES

TO ADD 14 LEGEND LIGHT DISPLAY (STATUS/CAUTION)

DOC. CLASS A
REV. CLASS II

OTHER DOCS. AFFECTED: REF. PC/SN R-1085 P.S. 2016041

EFFECTIVITY
HARDWARE: CUT-IN N/A CUT-OUT N/A
SPARES:

ORGANIZATION AFFECTED: MIT/RAYTHEON
NEXT HIGHER ASSY: PS 2016041
REMARKS:
DOCUMENT NUMBER REPLACED: N/A
INTERFACE AFFECTED: N/A

DISPOSITION OF PARTS ON HAND

DISPOSITION	PARTS	HIGHER ASSEMBLY	SPARES
NO CHANGE			
MODIFY			
SCRAP			

PREPARED BY Mirow
REF W. PLATT

DESIGN REVIEW APPROVAL MIT/IL
Eldon C Hall 12/20/68
W Stameni 20 Dec 68

MIT CCB APPROVAL
12-24-68
1/10/69

ENGINEERING APPROVAL MIT/IL

CONTRACTOR APPROVAL
10 Jan 69
1/10/69 12/20/68

NASA APPROVAL
NOT REQUIRED
CCA497-0278

REISSUE DATE: ______ REASON:

CCB INITIAL
MIT-
CONTR-
NASA-

TP8013

TDRR NO. 37183

010

VAULT MASTER

R-30689

JDC: 05393 REV: C1 PAGE 1 OF 3

INITIAL TDRR 32541 D.S. PGS. 3

JOB: DSKY TEST DATA

SUBSYSTEM: Apollo Guidance Computer

ASSY:

DESCRIPTION:

Record of DSKY test data.

Rev. Ltr.	Date	TDRR NO.	PAGES REVISED		APPROVAL	
			JDC	D.S.	MIT	NASA
A	5/18/6	33805	1, 2, 3	1, 2, 3	[illegible]	[illegible]
B	[illegible]-11-6	35871	ALL	ALL	[illegible]	[illegible]
C1			ALL	ALL		

REFERENCES:
PS 2016041
PS 2016007
PS 2016015

C1

IMPORTANT:

INTERVAL:

TOOLS AND MATERIAL:

A. PREPARATION

None Required.

PAGE#2 OF TDRR#37183

THIS IS A REPRODUCIBLE COPY OF A DRAWING DO NOT ALTER OR CHANGE IN ANY WAY.

DATE ______

JOB: DSKY TEST DATA
JDC: 05393 REV: B C1 PAGE 2 OF 3
SUBSYSTEM: Apollo Guidance Computer
ASSY:

B. PROCEDURE (Cont'd)

*1. Verify that each DSKY has been tested with the DSKY test station per PS 2003994 OR PS2016041 AS APPLICABLE without any indication of failure. Stamp data sheet. C1

*2. Verify that DSKY modules were inspected for mechanical defects during assembly. Stamp data sheet.

*3. Verify test results from PS 2003994 OR PS 2016041 AS APPLICABLE are included in data package. C1

*NOTE: Steps 1, 2 & 3 are to be performed prior to Vibration Tests.

**Step 4 is to be performed after Thermal Tests.

PAGE# 3 OF TDRR# 37183

THIS IS A REPRODUCIBLE
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CHANGE IN ANY WAY.

DATE ________

JOB: DSKY TEST DATA	JDC: 05393 REV: B C1 PAGE 3 OF 3
SUBSYSTEM: Apollo Guidance Computer	ASSY:

B. PROCEDURE

C1

**4. Measure and record the following data per the requirements of PS 2003994, OR PS 2016041 AS APPLICABLE,

a. Actual and average intensity of the following six (6) segments on each DSKY:

PROG
NOUN
VERB
3 Horizontal Bars

b. Intensity of COMP ACTY segment on each DSKY.

c. Actual and average intensity of the six (6) segments of the left PROG character positions on each DSKY. These segments are:

72J
71F
22K
16B
34K
31E

d. Actual and average intensity of all key E.L.'s on each DSKY.

e. Actual and average intensity of all alarm segments AND CURRENT FOR EACH ALARM SEGMENT

C1

PAGE # 4 OF TDRR # 37183

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DATE ________

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 1 OF 3

VAULT MASTER

JDC
NO. 05393
REV. ~~B~~ C1
INITIAL TDRR 32541

JOB: DSKY TEST DATA

ASSEMBLY UNDER TEST

TITLE Apollo Guidance Computer
SER. NO. ______ DWG. ______ REV. ______

TEST HISTORY

DATE ______ START ______ END ______ SITE/LOCATION
TIME ______ START ______ END ______ TOTAL ELAPSED

MAJOR GROUND SUPPORT EQUIPMENT

NAME ______ SER. NO. ______ ______ CAL DATE
NAME ______ SER. NO. ______ ______ CAL DATE

CONDUCTED BY ______ NAME/AFFILIATION
APPROVED BY ______ NAME/AFFILIATION

B. PROCEDURE

DSKY Results ~~DSKY #1~~

~~Results~~ ~~DSKY #2~~

4. Measure and Record

(a) Average intensity of six segments on ______ AV. ~~______ AV.~~

PROG ______
NOUN ______
VERB ______
3 Horizontal Bars ______
______
______

(b) Intensity of COMP ACTY segment ______ AV. ~~______ AV.~~

(c) Average intensity of six segments on left PROG character ______ AV. ~~______ AV.~~

72J ______
71F ______
22K ______
16B ______
34K ______
31E ______

PAGE# 5 OF TDRR# 37183

DATE ______

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 2 OF 3

JDC
NO. 05393
REV. ~~D~~ C

JOB: DSKY TEST DATA

B. PROCEDURE (Cont'd)

(d) Average intensity of all 19 key E.L.'s

	DSKY Results ~~DSKY #1~~	~~Results DSKY #2~~
	AV.	~~AV~~
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
+		
-		
VERB		
NOUN		
CLR		
STBY/PRO		
KEY REL		
ENTR		
RSET		

PAGE # 6 OF TDRR # 37183

DATE ________

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 3 OF 3

JDC
NO. [illegible]
REV. #C1

JOB: DSKY TEST DATA

B. PROCEDURE (Cont'd) DSKY Results ~~Results~~

(e) Average intensity of alarm segments & CURRENT.

	INTENSITY	AV. CURRENT
UPLINK ACTY		
NO ATT		
STBY		
KEY REL		
* (BLANK #1)		
OPR ERR		
* (BLANK #2)		
TEMP		
GIMBAL LOCK		
PROG		
RESTART		
TRACKER		
* ALT		
* VEL		

1. Each DSKY has been tested per PS 2003994 OR PS2016041 without any indication of failure ______ ______ Testman's Stamp

2. DSKY Modules have no evidence of mechanical defects as verified from previous inspection records ______ ______ Testman's Stamp

3. DSKY test results of PS 2003994 OR PS2016041 in data package ______ ______ Testman's Stamp

* THESE MEASUREMENTS ARE TO BE TAKEN ONLY ON DSKYS WITH 14 LEGEND STATUS/CAUTION INDICATORS.

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PAGE# 7 OF TDRR# 37183

DATE ______

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NAA S&ID	2/22/65
	SCd MIT	1/28/65

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT. NO. 03953

IRN NO.: 00617

ICD NO.: MH01-01220-216

TITLE:
Interconnecting Diagram-AGC to AGC DSKY (Main Display Panel)

NAA-MIT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ADDRESSEE

DESCRIPTION

In Zone 7:

Add connector Reference designation to MIT MDP Keyboard Connector and remove ⟨3⟩:

05A8J1 (was) ⟨B⟩

TDRR
31851
28 NOV. 1966

REASON:

DRN: T. Anderson 1/28/65

FORM M110-N-55 NEW 4-63

17 March 1967 IDRR 33203

AUTHORIZED SIGNATURES	REPRESENTING	DATE
R. Kennedy	NAA S&ID	2/6/67
wstamaria	MIT	8 Mar 67

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT NO.	IRN	№	
03953			3634

SYM.	DOCUMENT NUMBER	REV.
A	MH01-01316-116	A

TITLE:
EYEPIECE STOWAGE UNIT TO C/M STRUCTURE LEB., MIT-NAA S&ID

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ASSOCIATE CONTRACTOR

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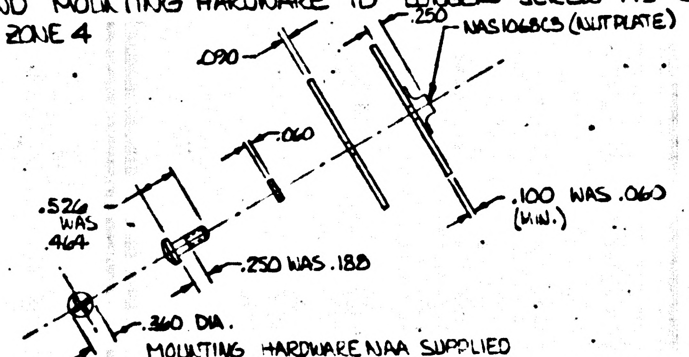
1 VELLUM	-
R.L. THOMAS ACELECT J. PIZZALA	CA99
1 VELLUM	
MICRO FILM REQ'S 3 MICRO DECKS	
5 COPIES	

DESCRIPTION:
CHANGE STRUCTURAL MOUNTING FLANGE THICKNESS TO .100 AND MOUNTING HARDWARE TO LONGER SCREW AS SHOWN IN ZONE 4



MOUNTING HARDWARE NAA SUPPLIED

SCREW 10-32 6 REQD NAS1133C4 WAS NAS1133C3
WASHER 6 REQD LD153-0002-2402

REASON: STRUCTURAL ANALYSIS OF THE .060 FLANGES WHICH SUPPORT THE EYEPIECE STOWAGE UNIT @ Yc± 11.813 INDICATES A LARGE NEGATIVE MARGIN OF SAFETY. REF NAA LETTER 696-204-66-024 TO F. MAYES FROM R.G. LINDSTROM.

DR. BY	DATE
F.H. DUNCAN	1-19-67
DEPT/GROUP	**EXT.**
697-506	2653
SHEET 1 OF 1	

FORM M 110-N-35 REV 9-65

SYMBOLS: $\boxed{A}$ = ATTACH IRN COPIES TO DRAWINGS

18 030

AUTHORIZED SIGNATURES	REPRESENTING	DATE
R.R.Kennedy	NAA-S&ID	4/15/66
W. G. Hoog	MIT/IL	S.A.H. 8 Feb 66

INTERFACE REVISION NOTICE

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT. NO 03953 | IRN № 3664

SYM.	DOCUMENT NUMBER	REV.
A	ICD MH01-01249-416	A

TITLE: G&N Thermal Requirements for Block I, Series 50 and 100 Apollo Guidance Equipment - NAA-MIT

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R. Kennedy	HB29
G. Gabelich	HA81
J. Percy	HC87
H.C. Beck	HB48

DESCRIPTION

Sheet 10 - Change Symbol:

—⊕— Brazed Connection

WAS

—+— Brazed Connection

DISTRIBUTION

	Dept/Group	Location	Qty
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~1~~
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			4 Vellums
Engineering Files			2 Microdecks
			5 Copies

TO RR 31845 23 NOV. 1966

[illegible] 44 Brb [illegible] 4 18-66

REASON:

Update Interface to Agree with Downey Operating Conditions

OFFICIALLY RELEASED

DR. BY E.Hickey DATE 2-4-66
DEPT/GROUP MIT/IL EXT. 1405
SHEET 1 OF 2

1966 APR 18 PM 3 30 BAS

FORM M 110-N-55 REV 9-65

2

SYMBOLS: [A] = ATTACH IRN COPIES TO DRAWINGS

4275 TRANS

INTERFACE REVISION NOTICE

Sheet 11 - Add the following:

Paragraph 1. Steady State Inlet Temperature

1.1 Equipment non-operating; IMU on heaters only. 60° to 90°F

1.2 Non-G&N equipment operating; IMU on heaters only. 65 ± 5°F

1.3 Ground checkout. G&N operating (exclusive of launch preparations) 65 ± 5°F. Surrounding structure and ambient temperatures will be maintained below 90°F during this mode.

1.4 Launch Preparation and Flight

IMU "Operate" Mode 45° ± 10°F

IMU "Standby" Mode 45° $^{+10°F}_{-5°F}$

1.5 Coolant Transient

The IMU shall meet performance requirements when subjected to coolant transients in accordance with the curve of sheet 12.

WAS

1. Steady State Inlet Temperature

IMU "Operate" Mode 45° ± 10°F

IMU "Standby" Mode 45° $^{+10°F}_{-5°F}$

Coolant Transient

The IMU shall meet performance requirements when subjected to coolant transients in accordance with the curve of sheet 12.

TO RR 31845 28 Nov. 1966

CODE IDENT NO.		
03953	IRN NO.	3664
	ICD NO.	MH01-01249-416
	SHEET	2 OF 2

FORM 2040-H REV 9-65

18 633

P - TR - TED

AUTHORIZED SIGNATURES	REPRESENTING	DATE
R A Kennedy	NAA-S&ID	4-...
TA W Stameris	MIT	11 Mar 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT. NO. 03953

IRN № 3663

SYM.	DOCUMENT NUMBER	REV.
A	MH01-01203-116	–

TITLE: BL. I PSA END CONNECTOR, POWER & SERVO ASSY TO C/M STRUCTURE, LWR EQUIP BAY-MIT-S&ID NAA

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ASSOCIATE CONTRACTOR

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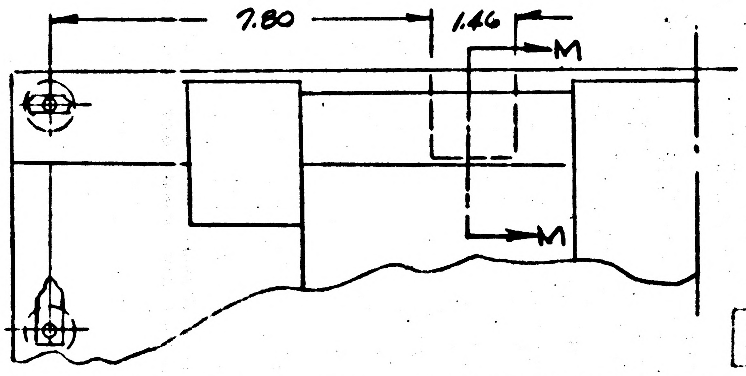
MICRO FILM REQMT	
3 MICRO DECK	
5 COPIES	

33 + 5 TRANS

DESCRIPTION

IN VIEW D-D, ZONE 7, ADD 7.80, 1.46 & SECT. MM AS SHOWN:



TORR
31851
28 Nov 1966

OFFICIALLY RELEASED

REASON:

TO PREVENT END CONNECTOR DEFLECTION DURING INSTALLATION OF TRAYS

DR. BY T. ANDERSON DATE 3-3-66

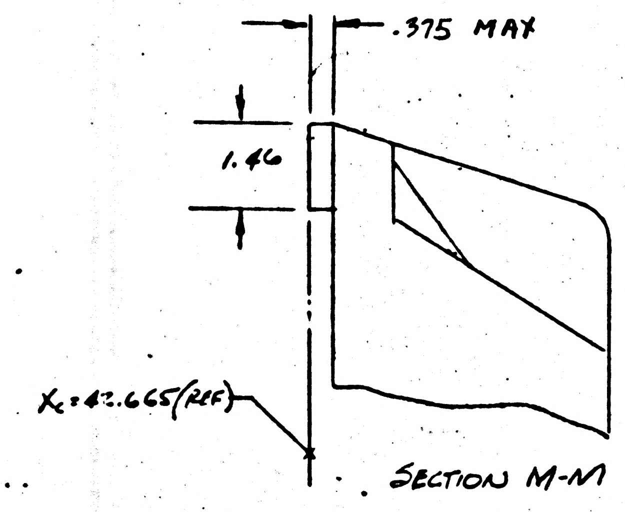
DEPT/GROUP MIT/IL EXT. 1312

SHEET 1 OF 2

2 SYMBOLS: A = ATTACH IRN COPIES TO DRAWINGS

WS 3/4/66

INTERFACE REVISION NOTICE



TORR
31851
28 Nov 1966

CODE IDENT NO. 03953	IRN NO.	3663
	ICD NO.	MH01-01203-116
	SHEET	2 OF 2

7/27 0900

27 155

(10 + 1T)

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	NAA-S&ID	7/21/66
	MIT/IL	1 July 66

INTERFACE REVISION NOTICE

INTERFACE CONTROL DOCUMENT

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

CODE IDENT. NO. 03953

IRN № 3690

SYM.	DOCUMENT NUMBER	REV.
A	MH01-01250-416	NC

TITLE:
Component Installation
Procedure-Block I Apollo
Guidance Equipment to C/M

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ASSOCIATE CONTRACTOR

RELEASE DATE 7-27-66

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DESCRIPTION

Change paragraphs 4.14.4, 4.14.6, to read as follows:

4.14.4 Obtain PSA tray 1 and install it into PSA End Connector while at the same time, the guide pins are engaging the mating holes in the toe cap. Observe the PSA tray peripheral gasket as the tray is inserted, using a light and inspection mirror as required. Ensure that the right side of the gasket is not caught by the mating connector and pulled into the area between the mating contacts.

4.14.6 Repeat the above procedures for the remaining trays in the following sequence: Tray 2, 3, 4, 5, 6, 7, 8, 9, 10.

Add paragraph 4.14.9 as shown:

4.14.9 Note: When it is necessary to remove any of the PSA trays, all trays to the right of the tray should be removed. Re-installation of the trays should be per the above paragraphs.

REASON:

To prevent improper sealing of PSA tray peripheral gasket.

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DR. BY	DATE
T.Anderson	[illegible]
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SHEET 1	OF 1

FORM M 119-U-58 REV 9-63

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SYM.	DOCUMENT NUMBER	REV.
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TITLE: GUIDANCE & NAVIGATION (G&N) THERMAL REQUIREMENTS FOR BLOCK I - SERIES 50 & 100 APOLLO GUIDANCE EQUIPMENT MIT-NAA

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN NAA AND THE ASSOCIATE CONTRACTOR

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DESCRIPTION

Sheet 5: MB0110-006 Rev. D (was) MB0110-006

Sheet 6:

Tray #1	95°F	(was	90°F)
Tray #2	105°F	(was	95°F)
Tray #3	93°F	(was	90°F)
Tray #4	93°F	(was	90°F)
Tray #5	95°F	(was	90°F)
Tray #6	105°F	(was	100°F)
Tray #7	105°F	(was	100°F)

Sheet 10: Delete code ⬡3 from Jumper Bypass

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REASON:

Sheet 5: To ensure identity of current procurement specification.

Sheet 6: To reflect a relaxation of temperature requirements made possible by recent M.I.T. testing and analyses.

Sheet 10. Requirements are in para 3 and note 1 page 11.

DR. BY	DATE
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FORM M 110-N-95 REV 9-65

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APOLLO II IRIG Specification
MC 25-880
Release Date 8 FEB 68
Release Revision —
Class A Release
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	~~NASA~~
8 FEB 68	—	35585	INITIAL RELEASE	R Booth 2-7-68	—

TP#11938

This MC specification consists of page 1 to___and 1 to 23 inclusive.

APOLLO 2 WHEEL ASSEMBLY PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo 2 wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races, shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer C-2021816, shall be, packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per MC 25-878. Inspect bearings per MC 25-887 for double honed parts and MC 25-887 and MC 25-892 for ball lapped parts. Check for oil wettability per MC 25-890.

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurement. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurement are made and record this information together with the average O.D. measurement on MC 25-886. Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para. 7.

1.5 Reclean the outer race per MC 25-878 as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. It is suggested that the oil be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
AMSCO Bag Sealer
Master Gage Plugs, Class XXX (.180000 .180020)
Sheffield Air Ring with two small jets for measuring the .180000-.180030 diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring .3748-.3749 diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2. INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC #25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture B-87392.

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F immerse wheel hub into liquid nitrogen, until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps d through g.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve A-87392.5 and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press

3.0 TEMPERATURE CYCLING

3.1 Wrap inertia element assembly in aluminum foil.

3.2 Place in the cycling container, #2A3-10B177. Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and +200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber
Reynolds Aluminum Foil

4.0 LAPPING BEARING BORES

4.1 Measure the lapping room temperature and, using the wheel assembly data

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 29.5" Hg vacuum minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ± 5°F and 29.5" Hg vacuum minimum, out gas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 29.5" Hg vacuum minimum for 18 hours, minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6 above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies #2A3-10A187-1 or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ± 5°F allowing 15-20 minutes for temperature to stabilize.

10.3.1.2 Remove from oven and install assemblies into centrifuge plate #2A3-10C187-1, or equivalent, and spin for 10 minutes ± 1/2 minute at 4000 ± 100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Place retainers between two pieces of lens tissue and store in oven at 150° ± 5°F for 3-6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percent (%) absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 Retainers shall be vacuum baked for five hours ± 15 minutes at 150° ± 5°F immediately prior to bearing assembly.

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet can be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per MC 25 878.

11.3 Clean wheel inertia element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ± 5°F and evacuate for one hour minimum at full vacuum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Assemble retainers, balls and outer races as follows:

12.1 With fixture A-118577 assembled, place outer race with stamped end up on shoulder of fixture A-118579.

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture A-118578.

12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy A-118577

12.5.1.1 Fixture A-118579

12.5.1.2 Fixture A-118578

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture #A-88948.3 with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with bone tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer B-97625 over the bearing and use fixtures A-88948.1 and A-88948.2 to press into the bore. The force necessary to push the bearing into the bore will be in the range of 3-8 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Screw adapter A-92246.2 into end 1 of the bearing shaft and holding only the adapter, guide the shaft through the wheel bore until the shaft end marked II replaces the plug inside bearing II. The wheel now is supported by the shaft. Reverse the position of the wheel and place this assembly on the fixture.

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture A-88948.1 and A-88948.2 to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements).

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen Head screws .187 long.

Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without, however, placing any preload on the bearings.

14 SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter #A-92246.1 to the #2 shaft end with the flat end inward and tighten to a torque of 0.75 in.lb (strain gage measurements at M.I.T. indicate that 0.75 in.lb of torque produce 76 microinches/inch shaft strain and correspondingly approximately 65 microinches shaft deformation).

The 65 microinches shaft strain will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION (Preload Fixture D-92272)

15.1 Assemble shaft adapter #A-92278, to the #2 end of wheel.

15.2 Assemble shaft cap #A-92277 to the #1 end of wheel. In assembly of these adapter insure that the applied torque does not exceed 0.75 in.-lb.

15.3 Preheat wheel in oven at 150 ± 5°F for 15 to 20 minutes. Remove wheel from oven and hand spin shaft to prelubricate raceways. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an addition 25-30 minutes and repeat prelubrication procedure.

15.4 Allow wheel to return to room temperature and position wheel on top plate #C-94190. The chain that is attached to shaft adapter #A-92278, should protrude through the bottom of the plate #C-94190.

15.5 Place clamping ring #C-94185, on top of wheel insuring that the teflon washer #A-94186 contacts the wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan #A-92281 to chain hanging from shaft adapter #A-92278.

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying three pounds load. Lift weight and zero meter and then gently apply the three poind load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

NOTE: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap #A-92277.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference point to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft approximately ± 45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ± 10 microinches, the proper preload has been achieved. If not, change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference. Repeat the above procedure starting with paragraph 15.4.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and recording the displacement of the indicator from zero for each weight. These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on MC-811.

15.14 Before preliminary dynamic balancing, position of cap, Dwg. C-2021669, shall be checked with cap centering ring #A92244. Remove socket head screws on number one end of wheel and replace with final 0-80 screws. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)
NOTE: Balancing may be performed after temperature cycle (17).

16.1 Remove the wheel from the compliance fixture. Place wheel in oven to preheat for approximately 5 to 10 minutes at 150°F. Remove wheel from oven and place in dynamic balancer. Wheel should be set at operating temperature as outlined in paragraph 20.1 With amplifier gain adjusted to 28 volts, run wheel up immediately to synchronous speed.

16.2 Dynamically balancing the wheel until the residual unbalance is no greater than 0.25 dyne-cm at 24,000 R.P.M. Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with rubber cups to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope and remove any trace of contamination. Before removing cups, clean the wheel thoroughly with suction hose.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 Wrap wheel in aluminum foil, and place in the cycling container, 2A3-10B177.

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.

Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.
Alt. Cycle: 32°F to 180°F

Equipment

Cycling Container	Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil	
Vacuum Pump	

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

Remove wheel from the dynamometer and place it in stand #A-88948.3. Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten firmly. Care should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per MC 25-304 may be used as an alternative material to tack screw heads.

19.1 With a microscope examine the area around the screw head and wipe off off any excess Loctite. (Loctite will not cure if exposed to air). Repeat this procedure to all 8 screws.

19.2 To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures #A-88948.3, A-92244.
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant
   American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per SCD 2021552.

20 DYNAMIC BALANCING (Final)

20.1 Check the final balance of the wheel as in paragraph 16 and make necessary corrections to achieve a maximum residual unbalance of 0.10 dyne-cm at 24,000 R.P.M. Also measure and record the bearing noise level.

NOTE: This check should be made with the wheel at operating temperature as follows:
The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.
2) Cover the stator housing and entire rotor platform with a foil lined beaker.
3) Run the wheel at synchronous speed until the Alnor meter indicates 155°-160°F. Wheel temperature will now be within the operating limits.

Equipment

Micro Dynamic Balancer, Model K-1
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
  Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust [illegible] particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

21.2 Clean off with vacuum hose and repeat 21.1.

21.3 Place the wheel in a covered glass container and store in moisture free atmosphere.

Equipment

Zeiss Stereo Microscope
Vacuum hose
Plastic bag
AMSCO Bag Seal
} or Equivalent

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure MC #25-855.

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter #A-95721, firmly to the VS-10.

22.2 Thread lock-nut #A-92357, to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter #A-95721 very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut #A-92357 firmly against the bushing, using spanner wrench #A-92359.

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 470-580 mv.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V.T.V.M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on M.C. #811 within ±0.25 microinch/lb.

22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on M.C. #811, insert wrench #A-92262 in the + SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench #A-92262, and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on M.C. #811, insert wrench #A-92262, and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values to be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in M.C. #25-605.

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 1.0 microinch/lb. If the term ΔC is greater than 1.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles).

Alternate cycle 32°F to 180°F at 4° / min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in M.C. #811. If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

22.14 Using a spade oiler, or other suitable tool, apply LCA 9, (SCD 202152?) MC 25-302, to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14 replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on MC 25-605.

22.19 Refer to MC 25-855 for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder #2A3-10A180-1.2 with the Fenwal Thermistor probe, into one of the IA balance ports.

23.2 Install the float into fixture #C-87364 and attach power and thermistor leads onto provided terminal strip.

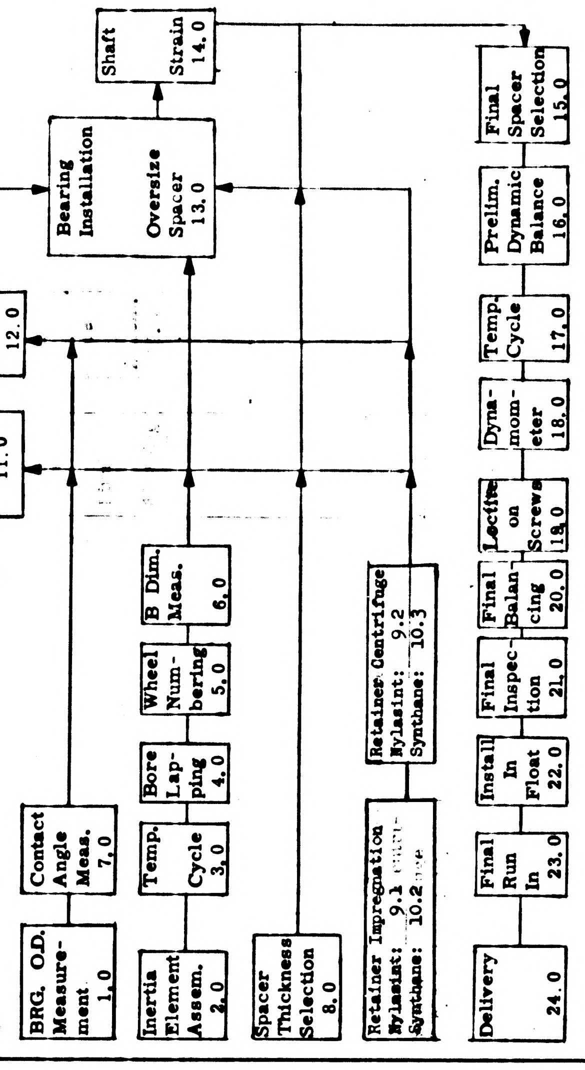
23.3 Install top plate #A-87364.1 on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 130°F minimum with wheel at 130°F minimum turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per MC 25-882.

24. DELIVERY

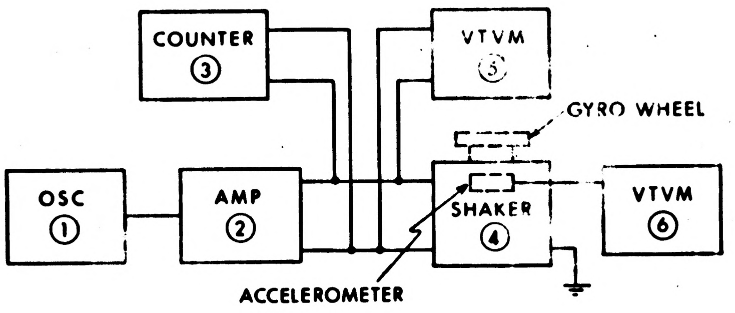
Continue float assembly per MC 25-855.


BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation Nylasint: 9.1 Synthane: 10.2
Retainer Centrifuge Nylasint: 9.2 Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation
Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Loctite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

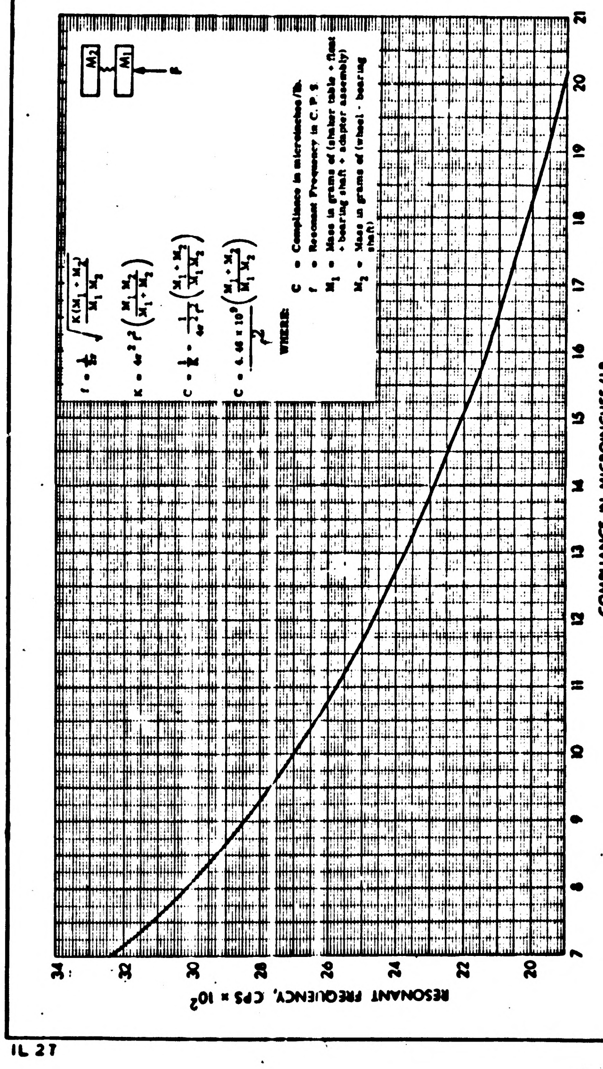
Fig. 1

Compliance Checking Equipment
Apollo 2 Gyro


COUNTER ③
VTVM ⑤
GYRO WHEEL
OSC ①
AMP ②
SHAKER ④
VTVM ⑥
ACCELEROMETER

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. V. T. V. M. - Ballantine Model 300E

Fig 2



RESONANT FREQUENCY VS. COMPLIANCE
For Wheel in Float
Measured by VS-10

FIG 3

APOLLO II IRIG Specification
MC 25-896
Release Date 7/5/68
Release Revision -
Class A Release
TDRR 36504

Title: Assembly of Microsyn Rotor to Holder

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
Ⓜ 7/5/68	-	36504	Initial Release	P.R.K.	R. Jacob

TP#11938

This MC specification consists of page 1
to ___ and 1 to 1 inclusive.

TDRR 36504 JUL 5 1968

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: 8 April, 1968
MC 25-896
SHEET 1
OF 1

ASSEMBLY OF MICROSYN ROTOR TO HOLDER

1.0 Preparation

1.1 Visually inspect the rotor holder assembly, 2021637, and the microsyn rotor, 2021692, for chips, burrs, loose laminations or damaged poles.

1.2 Clean the parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, followed by an ultrasonic rinse in clean freon for the same time period.

2.0 Rotor Cementing

2.1 Apply a bead of Epon 828 per MC 25-303 to the bottom of the microsyn rotor I.D. and assemble to the rotor holder. Wipe off any excess adhesive.

2.2 Place the assembly onto the rotor bonding fixture, B-118531 and cure for a minimum of 1 1/2 hours at 150° ± 5°F.

3.0 Sealing the Rotor Assembly

3.1 Heat the assembly to 115° ±5°F for 1/2 hour.

3.2 Apply Epon 828 between the inner rotor O.D. The holder I.D. also between the rotor holder O.D. and the microsyn rotor I.D. to form an unbroken fillet. Wipe off any excess adhesive.

3.3 Cure for a minimum of 1 1/2 hours at 150° ± 5°F.

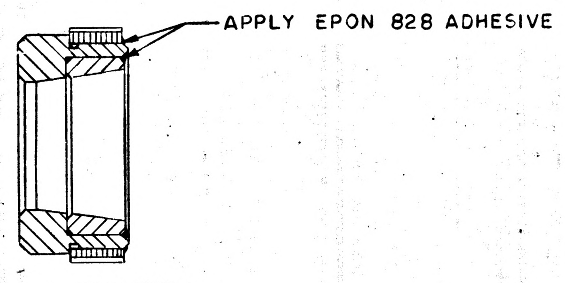


FIGURE I

APOLLO II IRIG Specification
MC 25-895
Release Date 7/5/68
Release Revision -
Class A Release
TDRR 36504

SUSPENSION ROTOR ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
ⓜ 7/5/68	-	36504	Initial Release	P.P.K.	R. Jacob

This MC specification consists of page i
to____and 1 to 1 inclusive.

TP#11938

TDRR 36504 JUL 5 1968

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE. MASS.

PREPARED BY: C. J. Cormier
DATE: April 16, 1968
MC 25-895
SHEET 1
OF 1

SUSPENSION ROTOR ASSEMBLY PROCEDURE

1.0 Preparation

1.1 Visually inspect the rotor holder, 2021691, and inner rotor, 2021690, for chips, burrs or inclusions.

1.2 Clean the parts in clean trichloroethylene ultrasonically for a minimum of three (3) minutes, followed by a ultrasonic rinse in clean freon for the same time period.

2.0 Cementing The Inner Rotor To The Holder

2.1 Apply a bead of Epon 828 per MC 25-303 to the bottom of the suspension rotor O. D. Push the rotor into the holder with a slight oscillating motion until it bottoms on the shoulder of the holder. Wipe off any excess adhesive.

2.2 Cure at 150° ± 5°F for 1 1/2 hours minimum.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: David P. Mason
DATE: February 4, 1964

MC 25-110

SHEET 1
OF 1

CARPENTER #49

High Permeability - Rotor Grade
(Carpenter Steel Co.)

ELECTRICAL SPECS.

Heat Treatment ______________________ MC 25-104

MAGNETIC LIMITS

ITEM	.006				.014	
	LAMS	CORES			LAMS	CORES
Core Loss Data 800 C. P. S., 6 Kilogauss						
Core Loss (W/lb.)	2.4	3.9			5.3	9.0
% Hysteresis Loss	40	35			38	20
% Eddy Current Loss	60	65			62	80
Hysteresis Loop Data, 10 C. P. S. -60 C. P. S.						
H Set (Oersteds)	.3	.5			.3	
B Min. (Kilogauss)	9.5	5.8			9.5	
μ Max.	65×10^3	20×10^3			65×10^3	
% Br	80	70			85	
% Hc	40	40			50	

Rev A 9-14-64

Notes

1. Test Method
   - a. Core loss data obtained by measuring the voltage applied to and current into a primary winding on the sample,and multiplying by the cosine of the angle between them, minus the primary copper loss. (Flux density having been set by voltage induced in a secondary winding.) Power supply must be a voltage source.
   - b. Hysteresis loop data obtained by sampling current into primary winding and displaying it on "X" axis of a calibrated "X-Y" recorder and by integrating the induced secondary voltage and displaying it on "Y" axis of recorder.
2. The values of sample area, volume, length, density and stacking factor used in above methods are calculated values based on lamination geometry and standard assumptions. (Specified by MIT)
   Carpenter #49 is extremely magnetostrictive and great care must be exercised in all mechanical operations performed on it. (Especially surface grinding.)

Ref. ABC-2569-A

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: D. P. Mason
DATE: July 9, 1963

MC 25-112

SHEET 1
OF 1

A

Rev A 9-18-64

MU-METAL

No. 2 Temper for Punching
(Allegheny Ludlum Steel Corp.)

Heat Treatment ______________________ MC 25-105

MAGNETIC LIMITS

ITEM		.006		.014	
		LAMS*	CORES	LAMS	CORES*
Core Loss Data 800 C.P.S., 2.5 Kilogauss		-	-	-	-
	Core Loss (W/lb)	.35	.50		
	% Hysteresis Loss	40	40		
	% Eddy Current Loss	60	60		
Hysteresis Loop Data, 10 C.P.S. -60 C.P.S.		-	-	-	-
	H Set (Oersteds)	.3	.3		
	B Min. (Kilogauss)	5.0	3.8		
	B Max. (")	6.0	5.1		
	μ Max.	80×10^3	55×10^3		
	% Br	73	73		
	% Hc	23	26		

MISC.

*(Bonded & Ground)

Ref. ABC - 2570

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David P. Mason
M. C. #25-104
SHEET 1 OF 1
DATE: January 3, 1962

Rev. A 4/30/63

HEAT TREATMENT PROCEDURE
for
CARPENTER NO. 49 LAMINATIONS

1. Degrease laminations.

2. Coat laminations with a slurry made of magnesium-oxide and is opropylalcohol with liquid detergent added to maintain suspension. A

3. Stack coated laminations, with poles aligned on a bolt or fixture and tighten hand tight.

4. Heat laminations to a temperature of 2100 degrees F plus or minus 20 degrees F in an atmosphere of hydrogen having a dew point of minus 60 degrees F. Hydrogen should flow continually over stack

5. Maintain temperature 4 hours.

6. Cool laminations to room temperature at a rate of 100-200 degrees F per hour. (In hydrogen atmosphere)

7. Unstack laminations and rinse in a 20% solution of boiling acetic acid. (Do not brush or stone laminations - Use great care to avoid bending.) A

8. Rinse laminations in hot tap water.

9. Rinse laminations in alcohol and air dry.

A Ref. ABC-2520

INCHES 0 1 2

APOLLO II IRIG Specification
MC No. 105
Release Date Nov. 4, 1964
Release Revision ~~A~~
Class A Release
TDRR 14046

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
1-15-65	B	15627	1	WK	WJR

TP#11938

This MC specification consists of page i to – and 1 to – inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: G. W. Lieber
M. C. 2 - #105
SHEET 1 OF 1
DATE: August 2, 1957

Rev. A: Rewritten and Retyped 22 November, 1957
Rev. B: 1/18/65

Hydrogen Annealing Procedure

1. Use hydrogen atmosphere of at least -70° F. dewpoint. Use appropriate ceramic packing in metal boats or appropriate jigs and fixtures to minimize any distortion.

2. Heat center of charge to between 1400 and 1450° F. for one hour with outside of charge being no more than 150° F. hotter than inside.

3. Slowly cool to 400° F. in not less than 10 hours and then expose to air to hasten cooling.

Reference ABC-229

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: Bertram Rockower
DATE: September 14, 1961 M.C. 25-102

SHEET 1
OF 1

Rev. B 10/15/63
Rev. A 2/21/63
Rev. C 9/1/64

BA

HEAT TREATMENT PROCEDURE FOR BERYLLIUM

This specification covers the heat treatment procedure to be followed in order to stress relieve beryllium after rough machining. BA

PROCEDURE

1. Rough machine to within approximately 0.010" of final dimensions.
2. Stress relieve in an inert atmosphere at 1450°F ± 25°F for 1 hour plus 1 hour for each inch or fraction thereof over 1 inch of cross section or diameter. Cool to 700°F at a rate not to exceed 100°/hour in an inert atmosphere. Cool to room temperature in still air. C
3. Cycle 5 times from -100°F to +200°F as outlined below:
    - (a) 1/2 hour at -100°F.
    - (b) 1/2 hour at room temp.
    - (c) 1/2 hour at +200°F.
4. Finish machine.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: Joseph Publicover
DATE: May 18, 1962

M. C. #25-103

SHEET 1
OF 1

Annealing of Mu-Metal

A. Preparation of Part to be Annealed.

1. Perform all mechanical operations on part before annealing.
2. Degrease part in trichlorethylene or similar solvent.
3. Prepare fused Magnesia, type -214, 46 mesh size (Norton Co. Refractories Div. , Worcester, Mass.) By heating to 2200°F. for 2 hrs. in a vacuum furnace to remove any residual volatiles.
4. Place part in a tray and cover it with fused Magnesia. Tamp lightly to fill any voids that might occur.

B. Heat Treatment.

C B

1. Anneal in a vacuum furnace* 2050°F ± 10°F For 4 Hours, Furnace cool to 1100°F. at a rate not to exceed 150°F. per hour. Cool to 600°F. at a rate no greater than 220°F. per hour. Air cool to room temperature.

Rev. B 5/18/62
Rev. C 9/1/64

* Pure dry Hydrogen atmosphere may be substituted.

IL 27

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: David P. Mason
DATE: March 23, 1962
MC 25-105
SHEET 1
OF 1

Heat Treatment Procedure for Mumetal Laminations

1. Degrease laminations.

C B 2. Coat the laminations with a slurry consisting of 3 parts by weight of 900 mesh of 900 mesh alundum and 7 parts by weight of anhydrous alcohol.

3. Stack coated laminations with poles aligned on a bolt or fixture and tighten hand tight.

4. Heat stacked laminations to a temperature of 2150 degrees F plus or minus 20 degrees F in an atmosphere of hydrogen having a dew point of minus 60 degrees F. Hydrogen should flow continually over stack.

5. Maintain temperature 4 hours.

6. Furnace cool laminations to 1100°F at a maximum rate of 100°F per hour.

7. Furnace cool laminations to room temperature.

CA 8. Unstack laminations and rinse in varsol, brushing lightly with a nylon brush. Repeat until all residue is removed.

C 9. Rinse laminations in cold water.

10. Rinse laminations in Acetone and air dry.

Rev. C 9/1/64
Rev. B 7/19/63
Rev. A 8/31/62

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: David P. Mason
DATE: March 23, 1962
MC 25-105
SHEET 1
OF 1

Heat Treatment Procedure
for
Mumetal Laminations

1. Degrease laminations.

C B 2. Coat the laminations with a slurry consisting of 3 parts by weight of 900 mesh of 900 mesh alundum and 7 parts by weight of anhydrous alcohol.

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6. Furnace cool laminations to 1100°F at a maximum rate of 100°F per hour.

7. Furnace cool laminations to room temperature.

CA 8. Unstack laminations and rinse in varsol, brushing lightly with a nylon brush. Repeat until all residue is removed.

C 9. Rinse laminations in cold water.

10. Rinse laminations in Acetone and air dry.

Rev. C 9/1/64
Rev. B 7/19/63
Rev. A 8/31/62

IL 27

INCHES
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PHOTOGRAPHIC SCALE ONLY

ABC-153-D

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: H. L. Watson M.C. 25-107 SHEET __

DATE: September 24, 1962 OF 1

HARDENING PROCEDURE FOR 3 1/2 per cent CHROME STEEL (SIMONDS #73) HYSTERESIS RINGS

Procedure:

1. Heat to between 1550°F. and 1575°F.
2. Hold temperature for at least 30 minutes.
3. Quench in oil. The material should be as near as possible to oven temperature, when it enters the oil.
4. Temper at 410°F. for 4 hours. The tempering should be started within 2 hours after the quench in oil. E

Explanation:

1. Steps one and two should form all austenite.
2. Step three insures that a maximum of austenite, $(\gamma = 1)$, will transform into martensite.
3. Step four helps transform the remaining austenite into martensite. If the tempering is not done shortly after quenching, it is more difficult to change the austenite into martensite.

Rev. E 3-8-63 HLW
Rev. D 5-15-62

TDRR 14363 NOV 18 1964

INCHES
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PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-200
Release Date 9-21-65
Release Revision --
Class A Release
TDRR 22584

Process Specification for Plating & Heat Treating Hemisphere Bores

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA

TP#11938

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

PROCESS SPECIFICATION FOR PLATING & HEAT TREATING HEMISPHERE BORES

1. MASKING - Clean the parts to be masked using a trichlorethylene vapor degreaser. Mask the part with Jones Chemical Milling Mask #1-300. Apply a minimum of four coats at fifteen to twenty-four hours before proceeding further. Trim masking from the areas to be plated using a sharp razon blade or other suitable instrument.

2. CLEANING _ Cathodically clean the parts in a Potassium Hydroxide solution having the following characteristics:

    a. Concentration - 50.0 ± 0.5 gm/liter
    b. Temperature - Room
    c. Time - 5 ± 1 min.
    d. Anodes - Stainless Steel (300 series)
    e. Current Density - 0.5 ± 0.25 amp/in^2
    f. Agitation - Moderate

    Thoroughly rinse with agitation in cold water.

3. ETCHING - Anodically etch the parts in a solution consisting of equal volumns of 85% Phosphoric Acid and deionized water plus 10 cc/liter of Hydrochloric Acid under the following conditions:

    a. Temperature - Room
    b. Current Density - 0.5 ± 0.25 amp/in^2
    c. Anodes - Nickel
    d. Time - 1 min. ± 10 sec.

    Rinse with agitation in cold water. Immerse and agitate the parts in an aqueous solution containing 100 ± 1 gm/ liter of Ammonium Sulfate and 50.0 ± 0.5 cc/liter of concentrated Sulfuric Acid at room temperature for one minute ± 10 sec. Rinse in cold water with agitation for a minimum of thirty seconds and then in deionized water with agitation for a minimum of thirty seconds.

4. STRIKING - Copper strike the parts by immersion with agitation for 5 ± 1 min. in a bath having the following characteristics:

    a. Copper Cyanide - 5.5 - 8.5 oz/gal.
    b. Free Sodium Cyanide - 1.0 - 2.0 oz/gal.
    c. Potassium Hydroxide - 1.2 ± 0.1 oz/gal.
    d. p^H - 12.8 - 13.3
    e. Temperature - 130° - 140°F
    f. Current Density - 20-30 amp/ft^2

---

5. PLATING - Nickel plate the parts by immersing with agitation in a bath having the following composition and conditions:

    a. Nickel Sulfate - 17.1 ± 0.1 gm/liter
    b. Sodium Hypophosphite - 14.0 ± 0.1 gm/liter
    c. Acetic Acid - 12 ± 1 ml/liter
    d. Molybdic Acid - Ref: Graph, F. M. 10,019
    e. p^H - 5.2 - 5.5 *
    f. Temperature - 185 - 195°F

    *Adjust with Sodium Hydroxide.

    This bath plates at a rate of 0.0005 to 0.0007 in/hr. requiring about eight hours for a 0.005 to 0.006 in. thickness. After plating is completed, remove the parts and rinse in cold water.

6. MASK REMOVAL - Remove the mask by peeling and immersion in Acetone. Air dry.

7. STRESS RELIEF - Relieve stresses by oven baking at 350° ± 10°F for three hours.

8. HARDENING - Harden the plating by heat treating in an Argon atmosphere at 750° ± 10°F for one hour (after the part has reached temperature) and air cool. Hardness shall be 62 RC minimum.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: May 16, 1963

SHEET 1
OF 1

MC-25-302

Rev. A 10/25/63

CEMENTING PROCESS

LCA-9 Adhesive with Activator BA-5
(BACON INDUSTRIES, Watertown, Mass.)

1. Weigh out, in a 2-ounce glass jar, twenty-five (25) grams of LCA-9. Note: If the compound appears hard or lumpy, heat in a 200°F oven for 1/2 hour. Allow to cool before proceeding to next step.

2. Add 1.1 grams of Activator BA-5. Stir thoroughly, using a metal stirrer (spatula or equivalent), until all of the activator is completely blended with the LCA-9. When this is accomplished the mixture will be a light green throughout with no evidence of streaks.

3. Parts to be sealed or joined should be thoroughly cleaned by prescribed methods and pre-heated to 160° - 180°F.

4. Cure

200°F for 2 hours.
180°F for 2-1/2 hours (Float Assembly).

APOLLO II IRIG Specification
MC 25 - 302
Release Date 18 Nov., 1964
Release Revision A
Class A **Release**
TDRR 14363

Cementing Process

LCA -9 Adhesive-Activator BA-5

				Approval	
Date	**Revision Letter**	**TDRR No.**	**Pages Revised**	**MIT**	**NASA**
3-24-65	B	17992	Revised & Rewritten	WAK.	W J Rhine

TP#11938

This MC specification consists of page i to ___ and 1 to 2 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: March 6, 1965

MC 25 - 302

SHEET 1 OF 2

Rev A 10/25/63
Rev B 3/24/65

Cementing Process
LCA-9 Resin with BA-5 Activator

Reference: Bacon Industries Inc; Watertown, Mass.

1. Mixing Adhesive:

1.1. Weigh out 25 grams of LCA-9 resin in a 2 ounce glass jar.

Note: If the resin appears hard or lumpy, heat in a 200°F oven for approximately 1 1/2 hours, then thoroughly stir contents. Allow to return to ambient temperature before proceeding to next step..

1.2. Add 1.1 grams of BA-5 activator. Stir mixture thoroughly, using a metal stirrer (spatula or equivalent), until all the activator is completely blended with the resin. When this is accomplished the mixture will be a uniform light green color throughout with no evidence of streaks.

2. Part Preparation:

2.1. Parts to be sealed or bonded should be thoroughly cleaned by prescribed methods and pre heated to 170±10°F for approximately 1/2 hour prior to application of adhesive.

3. Cure:

3.1. General Usage: 200±5°F for 2 hours+15 min., -0 min.
3.2. Float Assemblies: 180±5°F for 2 1/2 hours+15 min., -0 min.

4. Shelf Life:

4.1. Bulk Resin: 6 months when stored unopened at 80°F maximum.

4.2. Freshly Mixed:

4.2.1. 90 minutes maximum at 70±5°F.

4.2.2. 30 days from date of mixing when stored in suitable containers at - 40°F or less.

4.2.3. 6 months maximum at -70±10°F when purchased and stored in units of 3CC metal Freeze Pak tubes.

4.2.3.1. Units may be refrozen if exposure to room temperature does not exceed 1/2 hour.

4.2.3.2. Refrozen units may be used only for non-sealing applications.

5. Design:

5.1. A fresh batch of adhesive shall be used in all bonding applications except as stated in 4.2.3.

5.2. Adhesive must be stored in sealed containers if dry ice is used to maintain storage temperature.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: R. Booth
DATE: October 26, 1964
MC 25-304
SHEET 1

CEMENTING PROCESS

LCA- 4 ADHESIVE WITH ACTIVATOR BA-5

1. Parts to be sealed or joined should be thoroughly cleaned by prescribed methods and preheated to 125°F. ± 5°F.

2. Weight out, in a 2-ounce glass jar, 100 Pbw of LCA - 4 and mix thoroughly. Add 4.5 Pbw of BA - 5 and mix thoroughly.

3. Part should be held at 125°F. during application of adhesive.

4. Cure

Initial: 125°F. for 1 hour minimum
Final: 140°F. for 2 hours±5 minutes and 160°F. for 2 hours ± 5 minutes.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
MC 25-507
SHEET 1
OF 3
DATE:

Rev. A 9/2/64

I. Microsyn Potting

1. Insert the forming gasket (A-112983), the inlet pipe (A-122133), and the outlet pipe (A-110488) into the top mold plate (B-112982).

2. Insert the two fill hole plugs (A-113298) into the end housing from the bellows side. Using depth micrometers, measure the depth from the edge of the end housing down to the inner end of the teflon plugs. This depth is .420" max. Remove the plugs and trim if necessary.

A 3. Using an artist's brush, coat the O. D. of the end housing and the O. D. of the bottom mold plate with DC-20 or RAM 225 release.

4. Assemble the end housing to the top plate, lining up the buttons and orifices. Reinsert the two fill hole plugs. Assemble the bottom plate.

5. Holding the mold assembly together, position teflon gasket A-110491 on the bottom mold plate, then slide inner housing B-115779 down over the outlet pipe and pick up the guide pin.

6. Tip the outer housing C-110736 at a comforable angle and insert mold-inner housing assembly positioning the piston bore next to the thermoswitch.

7. Place potting mold upright.

8. Assemble top coverplate.

9. Assemble teflon gasket and outlet orifice to inner housing.

10. Assemble piston assembly onto mold. Adjust yoke screws so that piston "0" ring just enters inner housing bore.

A 11. Weigh out 90 grams (min.) of P-14 compound (SCD 2021535). Rubber gloves should be worn during all handling of compound and activator. Place in oven and heat to 212°F until fluid.

TDRR 14363 NOV 18 1964

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
MC 25-507
SHEET 2
OF 3
DATE:

12. Connect mold heaters to 110 volts. (Allow to heat at same time as compound.)

13. Connect overflow assembly (1 oz. jar, stopper) to potting mold.

14. Check tightness of mold by pulling vacuum down to 3000 microns.

15. Weigh out 2.8 grams of activator (P-14. part P). (32.2 to 1 of P-14 compound to activator.

16. Remove compound from oven and add activator. Mix very thoroughly with stirring rod under ventilation hood for one minute. (Fumes generated are toxic.) Then place in vacuum oven until initial frothing disappears - approx. 5 minutes.

17. Remove piston assembly from mold and pour in compound. Replace piston.

18. Connect overflow jar to vacuum pump. Pinch vacuum hose with a clamp.

19. Turn mold upside down on fixture, and remove clamp.

20. Degas 3 minutes, until vacuum levels out at about 1000 microns.

21. Return mold to right-side-up position. Continue degassing.

22. Take up on yoke screws slowly, allowing the piston to force the compound into the end housing and into the overflow jar. (Use two Spintite wrenches.)

23. Allow approx. 3/16 inch of compound to enter overflow jar. Stop vacuum pump and release vacuum.

24. Take up another turn or two on the yoke screws.

25. Remove overflow assembly from outlet orifice. Quickly screw outlet orifice cap in place, pull down snugly.

26. Take up on yoke screws until loading spring is compressed to its solid height.

TDRR 14363 NOV 18 1964

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
MC 25-507
SHEET 3
OF 3
DATE:

A 27. Allow to cure at least four hours at 160°F. (Thermoswitch setting in mold.)

28. Discard overflow jar and mixing container.

29. Clean copper fittings. (Blow out potting compound from copper tubes with an air hose.) Store in a jar of Cobehn solvent.

30. After curing, disassemble mold carefully.

31. Clean all parts of mold and store. Do not use solvents on teflon coated mold parts.

32. Make resistance measurements and Hi-pot. Record on MC 25-858.

33. Final cure and temperature cycle per MC 25-858.

TDRR 14363 NOV 18 1964

APOLLO II IRIG Specification
MC 25-507
Release Date Nov. 18, 1964
Release Revision A
Class A Release
TDRR 14363

Microsyn Potting

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/12/65	B	16569	1, 2 & 3	WK	JBM 2/…
7/5/68	C	36501	1, 2 & 3		--

TP#11938

This MC specification consists of page 1 and 1 to 3 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 36501 JUL 5 1968

PREPARED BY: David N. Kupelian
DATE: 16 April, 1968
MC 25-507 REV C
SHEET 1 OF 3

I. Microsyn Potting

B 1. Insert the forming gasket (A-112983), the inlet pipe (A-122133), and the outlet pipe (A-110488) into the top mold plate (B-112982). The inlet and outlet pipes should be 1/64 below flush in the mold.

2. Insert the two fill hole plugs (A-113298) into the end housing from the bellows side. Using depth micrometers, measure the depth from the edge of the end housing down to the inner end of the teflon plugs. This depth is .420" max. Remove the plugs and trim if necessary.

B A 3. Using an artist's brush, coat the O. D. of the end housing and the O. D. of the bottom mold plate with DC-20 or RAM 225 release. Wipe off excess with a "Kimwipe."

4. Assemble the end housing to the top plate, lining up the buttons and orifices. Reinsert the two fill hole plugs. Assemble the bottom plate.

5. Holding the mold assembly together, position teflon gasket A-110491 on the bottom mold plate, then slide inner housing B-115779 down over the outlet pipe and pick up the guide pin.

Rev. A 9/2/64

6. Tip the outer housing C-110736 at a comforable angle and insert mold-inner housing assembly positioning the piston bore next to the thermoswitch.

7. Place potting mold upright.

8. Assemble top coverplate.

9. Assemble teflon gasket and outlet orifice to inner housing.

10. Assemble piston assembly onto mold. Adjust yoke screws so that piston "0" ring just enters inner housing bore.

B A 11. Weigh out 90 grams (min.) of P-14 compound (SCD 2021535). Rubber gloves should be worn during all handling of compound and activator. Place in oven and heat to 212°F ±5° until fluid, approximately 45 minutes.

NOTE: If the compound in the container is hard and lumpy, pre heat to 212° F ±5° for 1 hour minimum and thoroughly mix with metal stirrer.

TDRR 14363 NOV 18 1964

IL 27

TDRR 36501 JUL 5 1968

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
DATE: 16 April, 1968
MC 25-507 REV C
SHEET 2 OF 3

B 12. Connect the mold to 110 volts. (Allow to heat at same time as compound.)

13. Connect overflow assembly (1 oz. jar, stopper) to potting mold.

14. Check tightness of mold by pulling vacuum down to 300 microns.

B 15. Weigh out 2.8 grams of activator (BA+1).

B 16. Remove compound from oven and add activator. Mix very thoroughly with stirring rod under ventilation hood for one minute. (Fumes generated are toxic.) Then place in vacuum oven until initial frothing disappears - approx. 1 to 2 minutes.

17. Remove piston assembly from mold and pour in compound. Replace piston.

B 18. Connect overflow jar to vacuum pump.

B 19. Turn mold upside down on fixture, and open vacuum valve.

B 20. Degas 1 to 2 minutes, until vacuum levels out at about 1000 microns.

21. Return mold to right-side-up position. Continue degassing.

22. Take up on yoke screws slowly, allowing the piston to force the compound into the end housing and into the overflow jar. (Use two Spintite wrenches.)

B 23. Continue degassing compound as it enters overflow jar for approximately 30 seconds. Stop vacuum pump and release vacuum.

24. Take up another turn or two on the yoke screws.

25. Remove overflow assembly from outlet orifice. Quickly screw outlet orifice cap in place, pull down snugly.

26. Take up on yoke screws until loading spring is compressed to its solid height, using the two spintite wrenches.

TDRR 14363 NOV 18 1964

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 36501 JUL 5 1968

PREPARED BY: David N. Kupelian
DATE: 16 April, 1968
MC 25-507 REV C
SHEET 3 OF 3

27. Allow to cure for four hours minimum at 212°F±5° and at a pressure of 270 ± 20 psia.

28. Discard overflow jar and mixing container.

29. Clean copper fittings. (Blow out potting compound from copper tubes with an air hose.) Store in a jar of Cobehn solvent.

30. After curing, allow mold to cool to room temperature 12 hours minimum. (Do not force cool) Carefully remove the potted assembly from the mold.

31. Clean all the mold parts and store. Do not use solvents on teflon coated mold parts.

32. Perform resistance measurements and cycle per MC 25-858.

33. Continue assembly per MC 25-857.

IL 27

APOLLO II IRIG Specification
MC 25-507
Release Date Nov. 18, 1964
Release Revision A
Class A Release
TDRR 14363

Microsyn Potting

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
2/12/65	B	16569	1, 2 & 3	WK	JBM 2/12/65
7/5/68	C	36501	1, 2 & 3		--
12/5/68	D	37096	2	MGM EA	WLS

TP#11938

This MC specification consists of page 1 and 1 to 3 inclusive.

I. Microsyn Potting

B 1. Insert the forming gasket (A-112983), the inlet pipe (A-122133), and the outlet pipe (A-110488) into the top mold plate (B-112982). The inlet and outlet pipes should be 1/64 below flush in the mold.

2. Insert the two fill hole plugs (A-113298) into the end housing from the bellows side. Using depth micrometers, measure the depth from the edge of the end housing down to the inner end of the teflon plugs. This depth is .420" max. Remove the plugs and trim if necessary.

B A 3. Using an artist's brush, coat the O.D. of the end housing and the O.D. of the bottom mold plate with DC-20 or RAM 225 release. Wipe off excess with a "Kimwipe."

4. Assemble the end housing to the top plate, lining up the buttons and orifices. Reinsert the two fill hole plugs. Assemble the bottom plate.

5. Holding the mold assembly together, position teflon gasket A-110491 on the bottom mold plate, then slide inner housing B-115779 down over the outlet pipe and pick up the guide pin.

6. Tip the outer housing C-110736 at a comforable angle and insert mold-inner housing assembly positioning the piston bore next to the thermoswitch.

Rev. A 9/2/64

7. Place potting mold upright.

8. Assemble top coverplate.

9. Assemble teflon gasket and outlet orifice to inner housing.

10. Assemble piston assembly onto mold. Adjust yoke screws so that piston "0" ring just enters inner housing bore.

B A 11. Weigh out 90 grams (min.) of P-14 compound (SCD 2021535). Rubber gloves should be worn during all handling of compound and activator. Place in oven and heat to 212°F ±5° until fluid, approximately 45 minutes.

NOTE: If the compound in the container is hard and lumpy, pre heat to 212° F ±5° for 1 hour minimum and thoroughly mix with metal stirrer.

B 12. Connect the mold to 110 volts. (Allow to heat at same time as compound.)

13. Connect overflow assembly (1 oz. jar, stopper) to potting mold.

14. Check tightness of mold by pulling vacuum down to 300 microns.

B 15. Weigh out 2.8 grams of activator (BA+1).

B 16. Remove compound from oven and add activator. Mix very thoroughly with stirring rod under ventilation hood for one minute. (Fumes generated are toxic.) Then place in vacuum oven until initial frothing disappears - approx. 1 to 2 minutes.

17. Remove piston assembly from mold and pour in compound. Replace piston.

B 18. Connect overflow jar to vacuum pump.

B 19. Turn mold upside down on fixture, and open vacuum valve.

20. Degas 2 to 3 minutes, until vacuum levels out at 100-500 microns.

21. Return mold to right-side-up position. Continue degassing.

22. Take up on yoke screws slowly, allowing the piston to force the compound into the end housing and into the overflow jar. (Use two Spintite wrenches.)

B 23. Continue degassing compound as it enters overflow jar for approximately 30 seconds. Stop vacuum pump and release vacuum.

24. Take up another turn or two on the yoke screws.

25. Remove overflow assembly from outlet orifice. Quickly screw outlet orifice cap in place, pull down snugly.

26. Take up on yoke screws until loading spring is compressed to its solid height, using the two spintite wrenches.

---

27. Allow to cure for four hours minimum at 212°F±5° and at a pressure of 270 ± 20 psia.

28. Discard overflow jar and mixing container.

29. Clean copper fittings. (Blow out potting compound from copper tubes with an air hose.) Store in a jar of Cobehn solvent.

30. After curing, allow mold to cool to room temperature 12 hours minimum. (Do not force cool) Carefully remove the potted assembly from the mold.

31. Clean all the mold parts and store. Do not use solvents on teflon coated mold parts.

32. Perform resistance measurements and cycle per MC 25-858.

33. Continue assembly per MC 25-857.

APOLLO II IRIG Specification
MC 25-605 C
Release Date Nov. 18, 1964
Release Revision B
Class A Release
TDRR 14363

Wheel Run In and Delivery Data

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
6/27/68	C	36394	1	PRL	

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

TP# 11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 36394 JUN 27 1966

PREPARED BY B. Rockower
DATE: January 5, 1962
MC 25-605 C
SHEET 1 OF 2

WHEEL RUN IN AND DELIVERY DATA

1. Wheel Number ______ Type ______
2. Running Torque ______ dyne-cm.
3. Residual Unbalance
   Side No. I ______ dyne-cm.
   Side No. II ______ dyne-cm.
4. Compliance
   Axial ______ microinches/lb.
5. Wheel weight ______ grams
6. Run in Frequency ______ c. p. s.
7. Rundown time ______ seconds (24000 R. P. M. to 6000 R. P. M. and 6000 to zero)
8. Total Running Time ______ hours.
9. Shaft Diameter (nominal .180000")
   A. Side number I (-SRA) ______
   B. Side number II (+SRA) ______

DATA DURING WHEEL IN FLOAT TEST

1. Power to start at 28 volts/phase ______ watts (total)
2. Current to start at 28 volts/phase ______ ma/phase
3. Time to sync. ______ seconds at 28 V/phase.
4. Average rundown time ______ seconds (24000 RPM to 6000 RPM)
5. RMS of RDT Deviation ______ seconds (24000 RPM to 6000 RPM)
6. Operating Temperature ______ °F.
7. Compliances (Microinches/lb)

	Initial	After LCA-9 Cure
Radial		
Axial		
Difference		

DATE ______

Rev. B 9/12/62 Retyped
Rev. A 1/5/62

TP# 7189

TDRR 14363 NOV 18 1964

Prepared by: B. Rockower

M.C. 25-605 WHEEL IN FLOAT RUN-IN DATA

2 of 2

WHEEL NO. ______
UNIT NO. ______

IMPRESSED VOLTAGE = 28 V/PHASE
OPERATING TEMPERATURE = 137°F

A_F = ______ SECONDS
σ_F = ______ SECONDS

DATE	START	STOP	TOTAL RUNNING TIME	TOTAL POWER IN WATTS: TO START AT 28 V/φ	TOTAL POWER IN WATTS: AT SYNC.	CURRENT MA/PHASE: TO START AT 28 V/φ	CURRENT MA/PHASE: AT SYNC	RUN-UP TIME IN SECS FROM 0-24000 R.P.M. AT 28V	RUN-DOWN TIME IN SECS 24000 TO 6000 / 6000 TO ZERO	COMPLIANCES IN MICROINCHES/LB BY VS-10: AXIAL	COMPLIANCES IN MICROINCHES/LB BY VS-10: RADIAL	COMPLIANCES IN MICROINCHES/LB BY VS-10: DIFFERENCE	TORQUE IN IN-LBS ON +SRA FLOAT BUSHING	REMARKS

Rev. A 1/5/62 Rev. B 9/10/62

TP# 7189 REV A 1/5/62 REV B 9/10/62

TDRR 14363 NOV 18 1964

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Ervin H. Lewis
DATE: July 30, 1963
M.C. 25-614
SHEET 1
OF 1

SPECIFICATIONS FOR ROTATIONAL BALANCE FLUID

(Frederick S. Bacon Laboratories 2.4/3/137 Newdamp Flotation Fluid)

1. Density

Nominal value of density to be 2.41 g/cm^3 at 137°F and not less than 2.40 g/cm^3 at that temperature. The fluid may be ordered to have a density of 2.3850 ± 0.0005 at 137°F.

2. Viscosity

Nominal value of viscosity to be 3 cps at 137°F and not more than 4 cps at that temperature.

3. Appearance

The material is to be free of dirt, water and sediment. It must be filtered before delivery.

4. Corrosiveness

The fluid shall remove no more than three steps from Randall Copper-Lead test strips when tested for 48 hours at 140°C.

5. Melting Point

The melting point shall be 100°F or lower.

TDRR 14046 NOV 4 1964

APOLLO II

1. Design Specifications (Preliminary)

A. Gyroscopic Element

1. Drive Stator

a. Type: Synchronous Hysteresis
b. Number of Poles: 4
c. Number of Phases: 2
d. Phase Rotation: A to B
e. Frequency: 800 cps
f. Angular Speed: 24,000 rpm

	At Start	At Synchronism
g. Impedance (Z):	111 + j102	121 + j107
h. Voltage (V):	28 volts	28 volts
i. Current (I):	185 ma	140 ma
j. Power (W):	7.6 watts	4.5 watts
k. Torque (T):	10,000 d-cm	7,500 d-cm

2. Wheel

a. Type of bearing Construction: Angular Contact Duplex DF Mounted with Adjustable Preload and Isoelasticity Capability.

b. Contact Angle: 31° ±1/2° at no load.
Contact Angle: 31 1/2° ±1/2° at 3 lb. load.

c. Inner Race Curvature: 54.0%.
Outer Race Curvature: 57.5%.

d. Breakaway Torque: Approximately 2000-2500 d-cm.

e. Running Torque at Operating Temperature: 600-1500 d-cm.

f. Windage Torque in Air: Approximately 3000 d-cm.

g. Preload: 2-4 lb.

Rev. A 6/29/64

---

h. Maximum Stress Inner Race: 208,000 psi.
Mean Stress Inner Race: 138,000 psi.

i. Axial Compliance at Operating Temperature:
9-12 microinches/lb.

Radial Compliance at Operating Temperature:
9-12 microinches/lb.

j. Bearing Run-in Time: 200 hrs.

k. Anisoelastic Torque Due to Bearing Compliance Difference (C = .75 microinches/lb. Max.): .017 d-cm/g^2.

l. Weight of Rotating Wheel Parts: 83.7 grams.

m. Moment of Inertia of Rotating Wheel Parts: 173 gram-cm^2

n. Angular Momentum at 24,000 rpm (H): .434 X 10^6 $\frac{\text{gram-cm}^2}{\text{sec.}}$

o. Time to Synchronous Speed at 28 volts in float: 90 sec. max.

p. Coast Down Time in Float to 6000 rpm: 130 sec. nominal.

B. Float Assembly

1. Size: 1.980 inch sphere.
2. Weight 184.0 grams.
3. Moment of Inertia:

About OA: 367.3 gram-cm^2
About IA: 650.8 gram-cm^2
About SRA: 724.9 gram-cm^2

4. OA Angular Freedom: 24 mr.
Minimum Angular Rotation From S.G. Null: 10 mr.
5. T.G. Null Alignment with Respect to S.G. Null: ± 1/2 mr.
6. Distance Between Suspension Rotor Centers: 2.48 inches.

---

7. Float Balance Range: 0 to 25 d-cm.
8. Float Balance Resolution: .070 d-cm (5° on balance adjustment).

C. Damper

1. Type: Brominated Fluorocarbon
2. Fluid Designation: 2400/137/2.385
3. Viscosity: 2400 centipoise at 137°F.
Viscosity Gradient: 42.2 centipoise/°F.
4. Density: 2.3850 grams/cc at 137°F.
Density Gradient: 10 X 10^{-4} grams/cc/°F.
5. Fluid Volume Gradient: 4.0 X 10^{-4} cc/cc/°F at 137°F.
6. Maximum Bellows Temperature Compensation: 180°F range.
7. Fluid Internal Pressure: 34 psi at 137°F.
8. Damping Coefficient

About OA: 4.75 X 10^5 d-cm/rad/sec.
About IA: 1.5 X 10^9 d-cm/rad/sec.
About SRA: 1.5 X 10^9 d-cm/rad/sec.

A

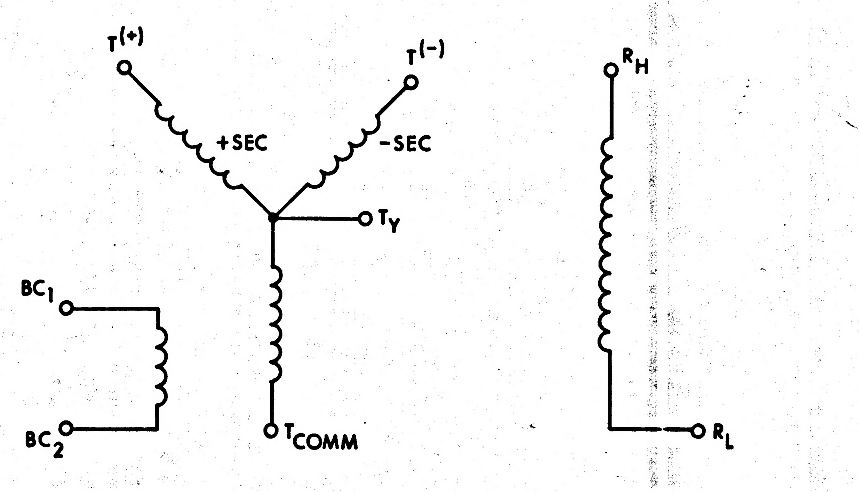
D. Signal Generator

1. Type: 12 MY-1.75-20A E-Connected Microsyn with 8-pole rotor.
2. Frequency: 3200 cps.
3. Input current: 17 ma
4. Input voltage: 4.0 volts
5. Maximum input current: 150 ma.
6. Null output voltage: 0.5 mv. compensated.
7. Sensitivity: 10 MV/MR
8. Air gap: .010 inch.

	Primary	Secondary
9. Turns per coil:	200	200
10. Wire Size:	#35	#35 AWG
11. D.C. Resistance at 135°F:	23 ohms	46 ohms
12. Impedance (3200 cps):	30 +j230 ohms	57 + j535 ohms
13. Reaction torque:	.05 dyne-cm max.	
14. Angular Elastic Restraint:	.025 dyne-cm	

E. Torque Generator

1. Type: 12 MY-1.75-21A Pulse Torqued, modified E-connection with residual reset winding, and bias compensation winding.



BIAS COMPENSATOR

RESET WINDING

2. Maximum input current: 130 ma.

3. Torque Sensitivity: $T^{(+)}$ or $T^{(-)}$ to T_{comm} = .6 dyne-cm/ma^2

4. Air gap: .010 inch.

		Primary	Torquing Winding	
			T(+)	T(-)
5.	Turns per coil:	400	200	200
6.	Wire size:	#38 AWG	#38 AWG	
7.	D.C. Resistance at 135°F:	92 ohms	92 ohms	92 ohms
8.	Inductance:	47 mh.	27 mh.	

9. Reset Winding: Impedance at 3200 cps 61 + j67 ohms
Max. input current 80 ma.
Residual magnetic torque
.01 dyne-cm. max at 45 ma, 3200 cps.

10. Bias Compensation Winding: 6 turns #38 AWG on pole #9
DC Resistance .6 ohms
Torque sensitivity with reset
winding 5.8 X 10^{-4} dc/ma^2

F. Magnetic Suspension

1. Type: T.I.S. - .750 - 4A - Tapered 20° included angle.
2. Frequency: 3200 cps.
3. Input Voltage: 4.0 V.
4. Current: 83 ma.
5. Damping Resistor: 7.0 ohms per gyro.
6. Working Capacitor: 0.055 ufd. nominal.
7. Air Gap: .003 inch
8. Impedance/coil pair: 106 + j1020 ohms

---

9. Winding: 2.5 Turns/coil #40 AWG

10. Radial Stiffness: 6 gm/.0001" Radial
0.8 gm/.0001" Axial

G. Temperature Sensor

1. Type: Thermistor
2. Number/Gyro: 2
3. Location in Unit: One in each End Housing suspended in fluid.
4. Nominal D.C. Resistance at 135°F: 345 ohms/one.
5. Operating Temperature: 135°F ± 2°F at the Thermistors.
Damping Gap Temperature: 137°F ± 2°F.
6. Temperature Gradient: 6 ohms/°F/Thermistor.
7. Stability: 1%.

H. Shroud Jacket

1. Functions:
    a) Provides Magnetic Shielding
    b) Provides a Vacuum Envelope for the Gyro.
2. Material: Mu Metal Main Cover, Stainless Steel End Covers.

A I. Gyro Constants

1. Time Constant $\left(\frac{I_{OA}}{C_{OA}}\right)$: 770 microseconds.
2. Angle In - Angle Out Sensitivity at 24,000 rpm $\left(\frac{H}{C_{OA}}\right)$: .942
3. Angle In - Voltage Out Sensitivity at 24,000 rpm
$\left(\frac{H}{C} \times S_{SG}\right)$: 9.4 mv/mr.
A 4. Angular Momentum at 24,000 rpm (H): .434 X 10^6 gm-cm^2/sec.
5. Damping Coefficient (C_{OA}): 475,000 d-cm/rad/sec.
6. Float Output Axis Inertia (I_{OA}): 367.3 gm-cm^2.

A 7. Signal Generator Sensitivity (S_{SG}): 10 mv/mr.

8. Gyro Pulse Scale Factor: $\frac{\pi}{2^{20}}$ rad/pulse at 3200 pps

J. Mechanical Characteristics

A 1. Without Shroud
    a) Size: 2.38 dia. X 3.680 in. long.
    b) Weight: 1.3 lb.
    c) Mounting: End Mounted
    d) Electrical Connections: 16 pins/end.

2. With Shroud
    A a) Size: 2.42 in. dia. X 3.750 in. long.
    b) Weight: 1.55 lbs.
    c) Mounting: End Mounted.
    d) Electrical Connections: 16 pins/end.

3. Prealigned
    a) Size: 2.810 dia. X 5.10 in. long.
    b) Weight: 1.97 lbs.
    c) Mounting: End Mounted.
    d) Electrical Connections: 26 pin continental connector.

APOLLO II IRIG Specification
MC 25-707
Release Date Nov. 4 1964
Release Revision A
Class A Release
TDRR 14046

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
1/18/65	B	15626	1	WK.	WJR

This MC specification consists of page 1 to - and 1 to 7 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: J.E. Publicover
DATE: February 20, 1964
MC 25-707
SHEET 1
OF 7

APOLLO II

B 1. Design Specifications (Preliminary)

A. Gyroscopic Element

1. Drive Stator

a. Type: Synchronous Hysteresis
b. Number of Poles: 4
c. Number of Phases: 2
d. Phase Rotation: A to B
e. Frequency: 800 cps
f. Angular Speed: 24,000 rpm

B

	At Start	At Synchronism
g. Impedance (Z):	128 + j942	115 + j164
h. Voltage (V):	28 volts	28 volts
i. Current (I):	176 ma	140 ma
j. Power (W):	7.9 watts	4.5 watts
k. Torque (T):	10,000 d-cm	7,000 d-cm

Rev. B 1/18/65
Rev. A 6/29/64

2. Wheel

a. Type of bearing Construction: Angular Contact Duplex DF Mounted with Adjustable Preload and Isoelasticity Capability.

b. Contact Angle: 31° ± 1/2° at no load.
Contact Angle: 31 1/2° ± 1/2° at 3 lb. load.

c. Inner Race Curvature: 54.0%.
Outer Race Curvature: 57.5%.

d. Breakaway Torque: Approximately 2000-2500 d-cm.

e. Running Torque at Operating Temperature: 600-1500 d-cm.

f. Windage Torque in Air: Approximately 3000 d-cm.

g. Preload: 2-4 lb.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: J.E. Publicover
DATE: February 20, 1964
MC 25-707
SHEET 2
OF 7

h. Maximum Stress Inner Race: 208,000 psi.
Mean Stress Inner Race: 138,000 psi.

i. Axial Compliance at Operating Temperature:
9-12 microinches/lb.

Radial Compliance at Operating Temperature:
9-12 microinches/lb.

j. Bearing Run-in Time: 200 hrs.

k. Anisoelastic Torque Due to Bearing Compliance Difference (C = .75 microinches/lb. Max.): .017 d-cm/g^2.

l. Weight of Rotating Wheel Parts: 83.7 grams.

m. Moment of Inertia of Rotating Wheel Parts: 173 gram-cm^2

n. Angular Momentum at 24,000 rpm (H): .434 X 10^6 $\frac{\text{gram-cm}^2}{\text{sec.}}$

o. Time to Synchronous Speed at 28 volts in float: 90 sec. max.

p. Coast Down Time in Float to 6000 rpm: 130 sec. nominal.

B. Float Assembly

1. Size: 1.980 inch sphere.

2. Weight 184.0 grams.

3. Moment of Inertia:

About OA: 367.3 gram-cm^2
About IA: 650.8 gram-cm^2
About SRA: 724.9 gram-cm^2

4. OA Angular Freedom: 24 mr.
Minimum Angular Rotation From S.G. Null: 10 mr.

5. T.G. Null Alignment with Respect to S.G. Null: ± 1/2 mr.

6. Distance Between Suspension Rotor Centers: 2.48 inches.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: J.E. Publicover
DATE: February 20, 1964
MC 25-707
SHEET 3
OF 7

7. Float Balance Range: 0 to 25 d-cm.

8. Float Balance Resolution: .070 d-cm (5° on balance adjustment).

C. Damper

1. Type: Brominated Fluorocarbon

2. Fluid Designation: 2400/137/2.385

3. Viscosity: 2400 centipoise at 137°F.
Viscosity Gradient: 42.2 centipoise/°F.

4. Density: 2.3850 grams/cc at 137°F.
Density Gradient: 10 X 10^{-4} grams/cc/°F.

5. Fluid Volume Gradient: 4.0 X 10^{-4} cc/cc/°F at 137°F.

6. Maximum Bellows Temperature Compensation: 180°F range.

7. Fluid Internal Pressure: 34 psi at 137°F.

A

8. Damping Coefficient

About OA: 4.75 X 10^5 d-cm/rad/sec.
About IA: 1.5 X 10^9 d-cm/rad/sec.
About SRA: 1.5 X 10^9 d-cm/rad/sec.

D. Signal Generator

1. Type: 12 MY-1.75-20A E-Connected Microsyn with 8-pole rotor.

2. Frequency: 3200 cps.

3. Input current: 17 ma

4. Input voltage: 4.0 volts

5. Maximum input current: 150 ma.

6. Null output voltage: 0.5 mv. compensated.

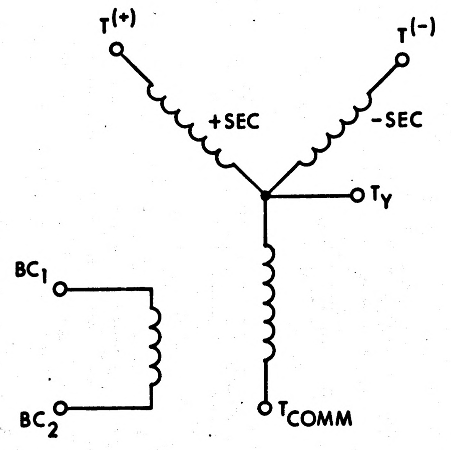
7. Sensitivity: 10 MV/MR

8. Air gap: .010 inch.

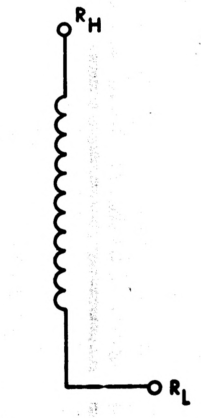
		Primary	Secondary
9.	Turns per coil:	200	200
10.	Wire Size:	#35	#35 AWG
11.	D.C. Resistance at 135°F:	23 ohms	46 ohms
12.	Impedance (3200 cps):	30 +j230 ohms	57 + j535 ohms
13.	Reaction torque:	.05 dyne-cm max.	
14.	Angular Elastic Restraint:	.025 dyne-cm	

E. Torque Generator

1. Type: 12 MY-1.75-21A Pulse Torqued, modified E-connection with residual reset winding, and bias compensation winding.



BIAS COMPENSATOR



RESET WINDING

---

2. Maximum input current: 130 ma.
3. Torque Sensitivity: $T^{(+)}$ or $T^{(-)}$ to T_{comm} = .6 dyne-cm/ma^2
4. Air gap: .010 inch.

		Primary	Torquing Winding T(+)	Torquing Winding T(-)
5.	Turns per coil:	400	200	200
6.	Wire size:	#38 AWG	#38 AWG	
7.	D.C. Resistance at 135°F:	92 ohms	92 ohms	92 ohms
8.	Inductance:	47 mh.	27 mh.	

9. Reset Winding: Impedance at 3200 cps 61 + j67 ohms
Max. input current 80 ma.
Residual magnetic torque
.01 dyne-cm. max at 45 ma, 3200 cps.

10. Bias Compensation Winding: 6 turns #38 AWG on pole #9
DC Resistance .6 ohms
Torque sensitivity with reset winding 5.8 X 10^{-4} dc/ma^2

F. Magnetic Suspension

1. Type: T.I.S. - .750 - 4A - Tapered 20° included angle.
2. Frequency: 3200 cps.
3. Input Voltage: 4.0 V.
4. Current: 83 ma.
5. Damping Resistor: 7.0 ohms per gyro.
6. Working Capacitor: 0.055 ufd. nominal.
7. Air Gap: .003 inch
8. Impedance/coil pair: 106 + j1020 ohms

---

9. Winding: 2.5 Turns/coil #40 AWG
10. Radial Stiffness: 6 gm/.0001" Radial
0.8 gm/.0001" Axial

G. Temperature Sensor

1. Type: Thermistor
2. Number/Gyro: 2
3. Location in Unit: One in each End Housing suspended in fluid.
4. Nominal D.C. Resistance at 135°F: 345 ohms/one.
5. Operating Temperature: 135°F ±2°F at the Thermistors.
Damping Gap Temperature: 137°F ±2°F.
6. Temperature Gradient: 6 ohms/°F/Thermistor.
7. Stability: 1%.

H. Shroud Jacket

1. Functions:
   a) Provides Magnetic Shielding
   b) Provides a Vacuum Envelope for the Gyro.
2. Material: Mu Metal Main Cover, Stainless Steel End Covers.

A I. Gyro Constants

1. Time Constant $(\frac{I_{OA}}{C_{OA}})$: 770 microseconds.
2. Angle In - Angle Out Sensitivity at 24,000 rpm $(\frac{H}{C_{OA}})$: .942
3. Angle In - Voltage Out Sensitivity at 24,000 rpm
$(\frac{H}{C} \times S_{SG})$: 9.4 mv/mr.
A 4. Angular Momentum at 24,000 rpm (H): .434 X 10^6 gm-cm^2/sec.
5. Damping Coefficient (C_{OA}): 475,000 d-cm/rad/sec.
6. Float Output Axis Inertia (I_{OA}): 367.3 gm-cm^2.

A 7. Signal Generator Sensitivity (S_{SG}): 10 mv/mr.

8. Gyro Pulse Scale Factor: $\frac{\pi}{2^{20}}$ rad/pulse at 3200 pps

J. Mechanical Characteristics

A 1. Without Shroud
   a) Size: 2.38 dia. X 3.680 in. long.
   b) Weight: 1.3 lb.
   c) Mounting: End Mounted
   d) Electrical Connections: 16 pins/end.

2. With Shroud
   A a) Size: 2.42 in. dia. X 3.750 in. long.
   b) Weight: 1.55 lbs.
   c) Mounting: End Mounted.
   d) Electrical Connections: 16 pins/end.

3. Prealigned
   a) Size: 2.810 dia. X 5.10 in. long.
   b) Weight: 1.97 lbs.
   c) Mounting: End Mounted.
   d) Electrical Connections: 26 pin continental connector.

APOLLO II IRIG Specification
MC 25-713
Release Date 21 July '69
Release Revision —
Class A Release
TDRR 37700

Title: SRG 160 Oil Absorption Test Procedure for Apollo II Nylasint Retainers

Date	Revision Letter	TDRR No.	Pages Revised	Approval	
				MIT	NASA

TP#11938

This MC specification consists of page i to ___ and 1 to 5 inclusive.

SRG 160 Oil Absorption Test Procedure for Apollo II Nylasint Retainers

1.0 SCOPE

1.1 This specification outlines an oil absorption test for retainers. The time required for oil absorption is an indication of the amount of salt blasting performed on the retainer surfaces (see MC 25-921).

2.0 NYLASINT RETAINER PROCESSING

2.1 Before conducting oil absorption test the nylasint retainer shall be processed per paragraphs 6c, 6d, and 6e of MC 25-921.

3.0 OIL ABSORPTION PROCEDURE (Pockets and Inner Diameters)

3.1 Place processed retainer of Para. 2.0 above under microscope at 30X and apply .010 ± .002 inches diameter drop of SRG 160 oil on center of retainer ball pocket using oil applicator (C-159730) as shown in Fig. 1.

3.2 Immediately tilt the retainer slightly so that the microscope light will cause surface of applied oil drop to reflect light.

3.3 When reflection of oil on retainer pocket has disappeared, the oil will have been completely absorbed (see illustrations 1-5 Fig. II).

NOTE: The time (measured in seconds with a stop watch) is the time required for a drop placed on retainer surface to disappear as stated above. The oil drop is considered to be completely absorbed when reflection of oil completely disappears. The length of time of absorption shall be recorded. The desirable range is 25 to 180 seconds.

3.4 Repeat procedures of paragraph 3.1, 3.2, and 3.3 on at least a total of 3 pockets per retainer.

3.5 Repeat procedure outlined in paragraphs 3.1, 3.2, and 3.3 for inner diameter of each retainer (see Fig. III).

NOTE: The desirable range for length of time of absorption shall not be less than 25 seconds nor more than 180 seconds.

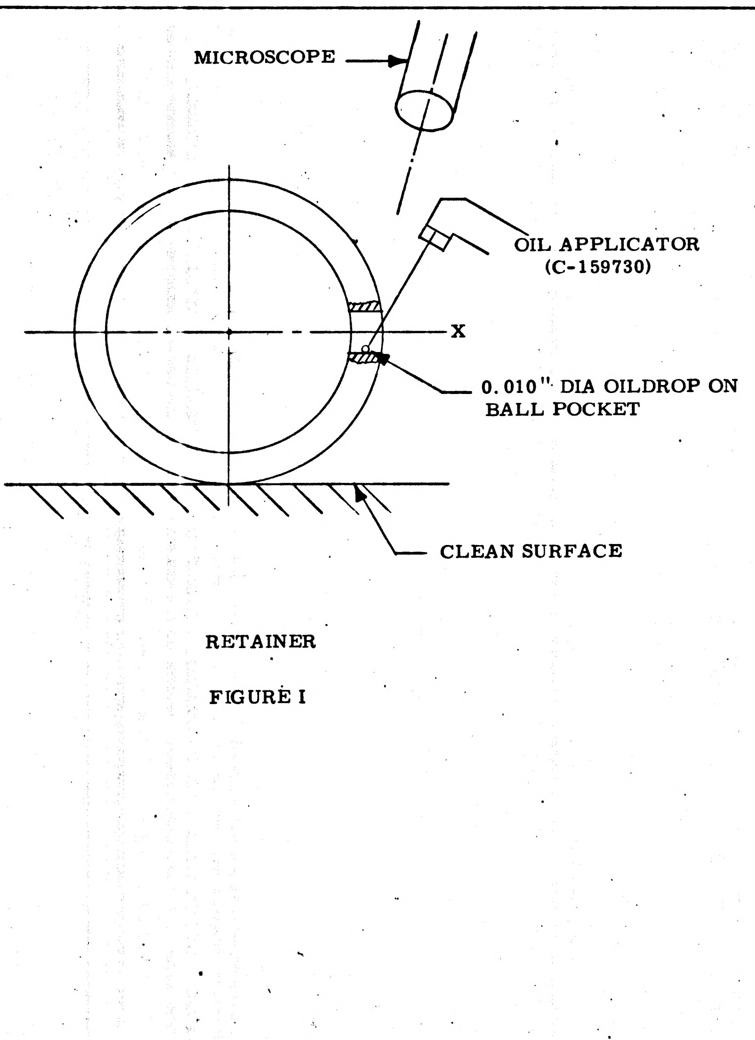
3.6 Following the oil absorption test of this specification reclean retainers per para. 6c, 6d, and 6e of MC 25-921.

3.7 General Notes

3.7.1 Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

3.7.2 When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

3.7.3 The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.



RETAINER

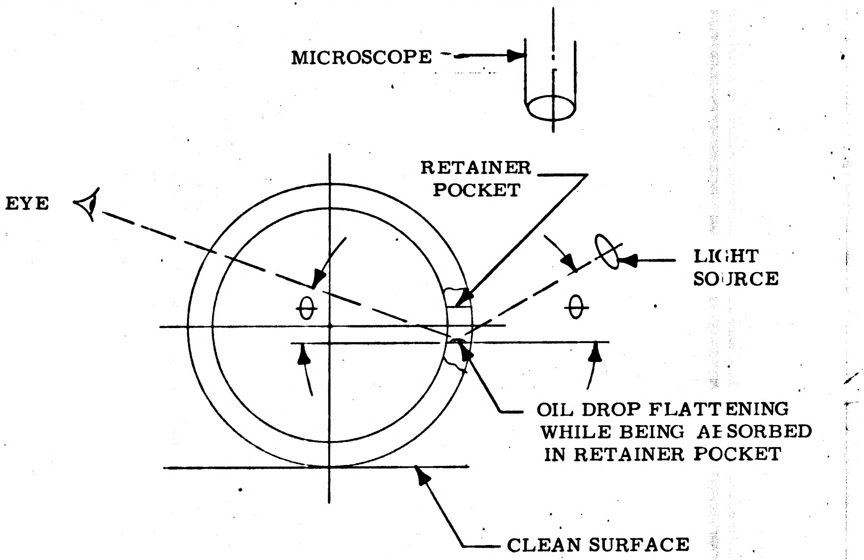
FIGURE I

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY B. Rockower
DATE: 13 May 1969

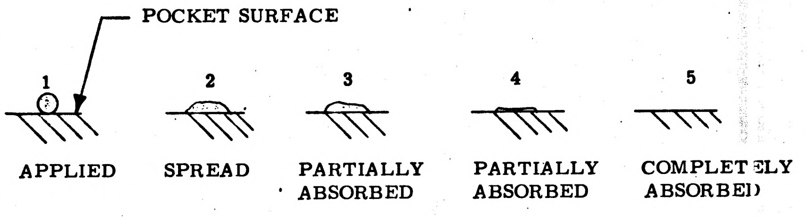
MC 25-713

SHEET 4
OF 5


MICROSCOPE
RETAINER POCKET
EYE
LIGHT SOURCE
θ
θ
OIL DROP FLATTENING WHILE BEING ABSORBED IN RETAINER POCKET
CLEAN SURFACE

RETAINER - NYLASINT

NOTE:
θ IS THE ANGLE AT WHICH SURFACE OF OIL APPEARS SHINY BEFORE ABSORPTION (VARIES FROM 15° TO 60°)


POCKET SURFACE
1
2
3
4
5
APPLIED
SPREAD
PARTIALLY ABSORBED
PARTIALLY ABSORBED
COMPLETELY ABSORBED

RETAINER POCKETS (ILLUSTRATION OF ABSORPTION)

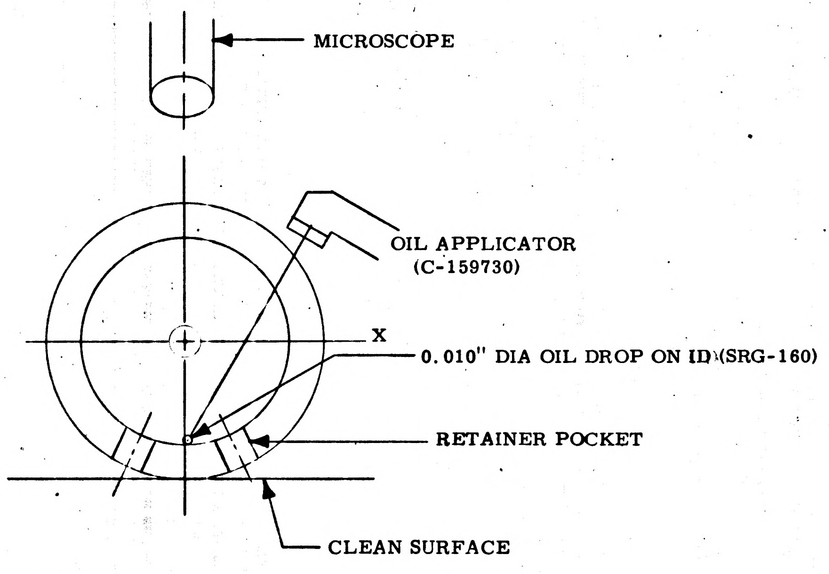
FIGURE II

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

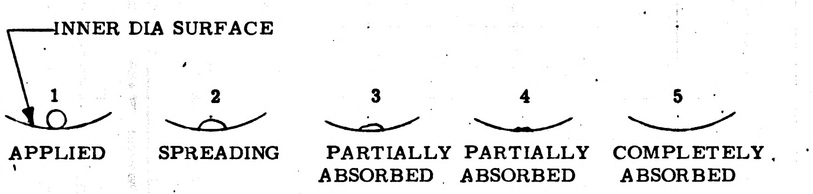
PREPARED BY B. Rockower
DATE: 13 May 1969

MC 25-713

SHEET 5
OF 5


MICROSCOPE
OIL APPLICATOR (C-159730)
X
0.010" DIA OIL DROP ON ID (SRG-160)
RETAINER POCKET
CLEAN SURFACE

RETAINER - NYLASINT


INNER DIA SURFACE
1
2
3
4
5
APPLIED
SPREADING
PARTIALLY ABSORBED
PARTIALLY ABSORBED
COMPLETELY ABSORBED

RETAINER INNER DIA (ILLUSTRATION OF ABSORPTION)

FIGURE III

APOLLO II IRIG Specification
MC 25-880
Release Date 8 FEB 63
Release Revision —
Class A Release
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	~~NASA~~
(M) 8 FEB 68	—	35585	INITIAL RELEASE	R Booth 2-7-68	—
(M) 8/1/68	A	36624	All, except 8, 20, 24.	B Rockower 9-17	—

This MC specification consists of page i to ___ and 1 to 24 inclusive.

TP#11938

MC 25-880 REV A

APOLLO II WHEEL PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo II wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer (C-2021816) shall be packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per (MC 25-878). Check and inspect the bearing surfaces. No defects will be accepted on balls and critical areas of inner and outer races as defined by fig. 1 (MC 25-887) (e.g., corrosion, brinelling, burrs, stains, gage marks, raised metal, tears, cuts, scratches, stringers, nicks, dents, digs, gouges, comets, pits, and inclusions). Check for oil wettability per (MC 25-890).

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurements. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurements are made and record this information together with the average O.D. measurement on (MC 25-886). Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para 7.

1.5 Reclean the outer race per (MC 25-878) as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. The oil shall be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
Quick Seal type 150 Natl. Inst. Co., Baltimore, Maryland
Master Gage Plugs, Class XXX (.180000-.180020)
Sheffield Air Ring with two small jets for measuring the (.180000-.180030) diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring (.3748-.3749) diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749, .3750, .3751)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2.0 INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC. 25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture (B-87392).

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F, immerse wheel hub into liquid nitrogen until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps 2.6 through 2.8.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve (A-87392.5) and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press
Simpson Model 388 thermocouple indicator or equivalent.

3.0 TEMPERATURE CYCLING

3.1 Place in a suitable closed glass container.

3.2 Place in the cycling container, (2A3-10B177) Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and +200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber

4.0 LAPPING BEARING BORES

NOTE Insure that all finished 0-80 tapped holes of hub element have been lapped.

4.1 Measure the lapping room temperature and using the wheel assembly data

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APOLLO II IRIG Specification
MC 25-890
Release Date ____________
Release Revision --
Class A Release
TDRR 35599

OIL WETTABILITY TEST PROCEDURE FOR APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
ⓜ 13 FEB 68	—	35599	INITIAL RELEASE		
ⓜ 8/1/68	A	36610	Revised & Rewritten		--

TP#11938

This MC specification consists of page 1 to ___ and 1 to 4 inclusive.

A-14

15

OIL WETTABILITY TEST PROCEDURE FOR APOLLO II IRIG

1.0 Bearing Parts of Preparation

1.1 Clean parts per (MC 25-878

2.0 Preparation of oil drop applicator (Dwg. C-159730)

2.1 A .002" dia platinum wire is fastened on applicator by means of mylar tape extending 1/4" to 3/8" beyond the end of applicator. The wire is flame-cleaned using alcohol lamp. The wire must be heated to a bright orange color and allowed to cool. Repeat this procedure 4-6 times to ensure sterilization and cleanliness. (See fig. 1)

3.0 Oil Drop Size and Placement

3.1 The size of collected drop on the platinum wire may be adjusted by varying the positioning screw on oil drop applicator (Dwg. C-159730) to produce an 021 ± .001 in. dia. drop for outer race, .016 ± .001 in. dia. drop for shaft races. (See fig. 1) and .011 ± .001 in. dia. drop on each of seven balls in holding fixture (Dwg. B-168447) (See fig. 6). Drop size is determined at 40 X using a 20 X calibrated eyepiece (Will Scientific Inc.). The eyepiece has 10 mm field width and is graduated in 0.1 mm. Calibration is obtained by a stage micrometer as a standard.

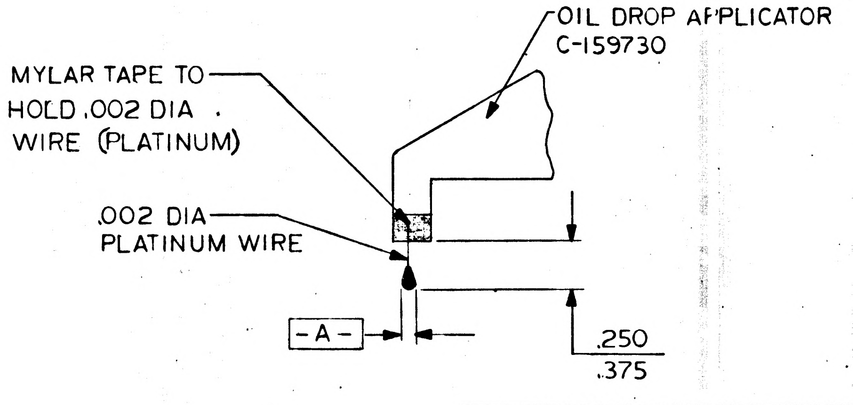
3.2 The correct size drop is placed on center of inner or outer raceway and on balls. (See figures 2, 3 and 6.) Using microscope for observation the drop is deposited by slowly approaching the raceway or ball with the wire. Care should be taken not to contact raceway or ball surface.

3.3 Place outer rings and shafts on holding fixture rod with axes in horizontal position. Drop position relative to race shall be in 12 o'clock position as illustrated in (Figures 4 and 5). Parts should be located in a dust free area and covered.

16

4.2 A wettable race or ball surface is when after 16 hours one-third or more of the circumference of raceway or ball surfaces is covered with lubricant.

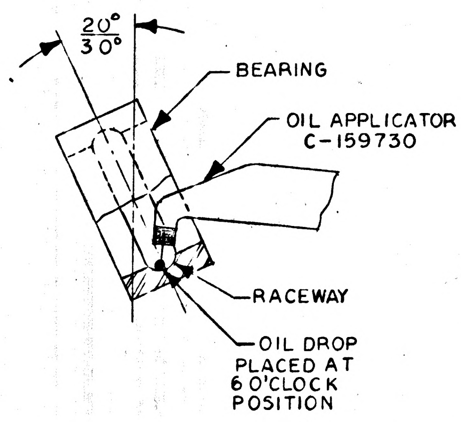
4.3 If raceway or ball surface is non-wettable, part shall be recleaned per (MC 25-878) and wettability test per this specification repeated. If part is still non-wettable it shall be subjected to acetone soxhlett extraction for 16 hours and wettability test procedure repeated. If part is still non-wettable it shall be rejected.



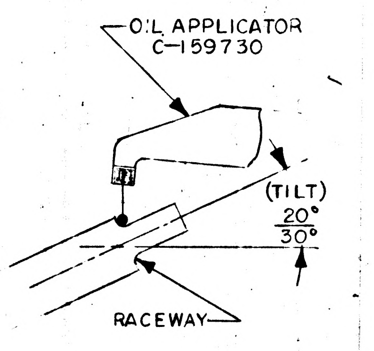
	DIM -A-
1. OUTER RACES (R2 BEARING)	0.021 ±.001 IN DIA
2. SHAFT RACES (R2 BEARING)	0.016 ±.001 IN DIA
3. BALL (R2 BEARING)	0.011 ±.001 IN DIA

FIGURE 1

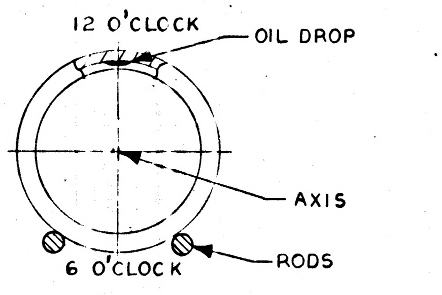
17



R-2 OUTER RACE
FIG. 2

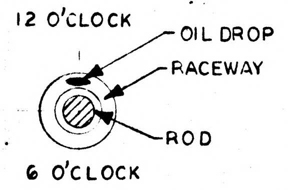


R-2 SHAFT RACE
FIG. 3



AFTER DROP PLACED ON FIG 2 ABOVE
REST ON ROD 16 HOURS FOR WETTABILITY

OUTER RACE
FIG. 4



AFTER DROP PLACED ON
FIG 3 PLACE ON ROD
16 HOURS FOR WETTABILITY

SHAFT RACE
FIG. 5

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964 MC 25-860
SHEET 1
OF 3

PROCEDURE FOR TESTING TG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

1.1 Mount rotor and stator on an air bearing torque test fixture device DRC-67-M-3 or equivalent. A

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5% F during testing.

1.3 Rotor ID run-out torque-summing member shall be 0.00005" TIR max. A

1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted. A

2.0 Magnetic Suspension

2.1 2.1 Connect and excite the assembly per Fig. 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating for minimum E_o.

2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1°. and I_m = 83 ± 6 ma.

2.5 Disable T_{comm}. Measure and record suspension reaction torque. (0 ± 0.3 dyne-cm) A

Rev. A 11/9/64

3.0 Torque Generator

3.1 Reconnect per Fig. 2 and adjust for null.

3.2 Connect and excite per Fig. 3A and measure current-squared squared torque sensitivity.

3.3 Repeat per 3B. If + and — torque sensitivities are not equal, dummy direct torque summing member to a new angle. Check + and — sensitivities until they are equal within 1%. Record sensitivities. During this test, check radial centering, but disable suspension while torque measurements are being made.

3.4 Reconnect per Fig. 2.

3.5 Measure and record magnitude and relative phase of E_o at the angle found in 3.3. This information will be used in Dry Centering Procedure MC 25-854.

TDRR 14531 NOV 25 1964

3.6 Place an indexing mark on the + or — IA axis of the rotor. This information is used in Final Assembly Procedure MC 25-853, step 2.A.5.

A 4.0 Bias Winding

4.1 Disable suspension and TG, zero all airbearing torque.

4.2 Measure and record the torque sensitivity of the bias winding. Connect reset coil and bias winding in series. Excite with 20 and 40 ma at 3200 cps. Average and record the torque sensitivity. Do not exceed 100 ma.

5.0 Residual Torque Test

5.1 Use residual torque testing electronics dwg #D128144.

5.2 Disable suspension and TG. Zero out all air bearing torques.

5.3 Apply 3 pulses to T+ winding. Read torque.

5.4 Apply 3 pulses to T- winding. Read torque. Calculate the difference in torque readings. Record.

5.5 Apply 50 ma at 3200 cps to the reset winding and repeat 5.3 and 5.4. Record Δ torque.

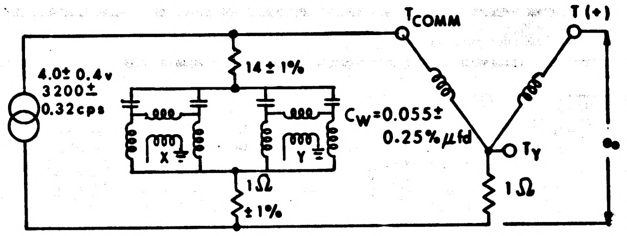


Fig. 1

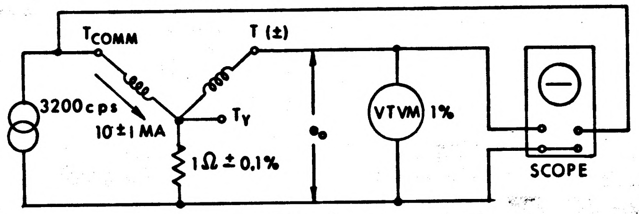


Fig. 2

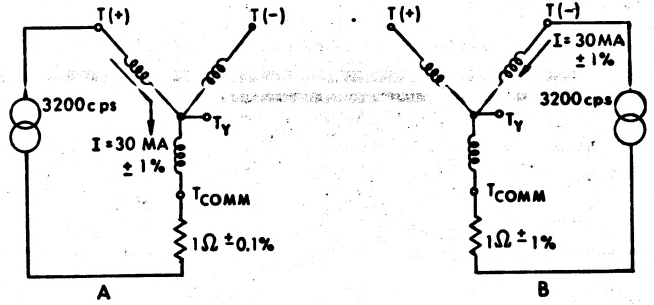


Fig. 3

APOLLO II IRIG Specification
MC 25-850
Release Date 18 Nov . 1964
Release Revision -
Class A Release
TDRR 14363

Unit Flotation Test

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
6/8/65	A	20016	1, 2	WK	

This MC specification consists of page i ~~to~~ ___ and 1 to 3 inclusive.

TP# 11938

Rev A 6-3-65

PREPARED BY: Louis Bertolami
DATE: February 25, 1964
MC 25-850
SHEET 1 OF 3

Title: Unit Flotation Test
Equipment: North Atlantic Phase Angle Voltmeter VM 204 or Equivalent
Note: All voltage measurements are made with a phase angle voltmeter to insure in phase voltages are measured.

I. Unit Orientation: IA Horizontal, + SRA up

1. With the unit excited as required in procurement specification, stabilize for at least 30 minutes.

   Record the radial voltages (Sx, Sy, Tx, Ty) on chart I.

II. Unit Orientation: IA Horizontal + SRA Down

2. Allow radial signals to settle for at least 10 minutes and record voltages (Sx, Sy, Tx, Ty).

   NOTE: By varying the temperature and noting the radial voltage drift, you can determine whether flotation is above or below operating temperature. It is advisable but not absolutely necessary to have the sample temperatures on either side of flotation.

A

3. Change temperature approximately 2°F from normal operating temperature in the direction as determined above.
4. Repeat step 1.
5. Repeat step 2.
6. Obtain from chart I the radial voltage differences for each axis and plot on graph I.
7. Draw straight lines connecting the two temperature radial difference measurements for each axis (Sx, Sy, Tx, Ty).
8. Note the zero crossover points of each radial axis and average the temperatures indicated. This is the flotation temperature.

MC - 25 850

PREPARED BY: Louis Bertolami
DATE: February 25, 1964
MC 25-850
SHEET 2 OF 3

CHART 1

GYRO ORIENTATION IA HORIZONTAL			RADIAL VOLTAGES S_X	S_Y	T_X	T_Y
OPERATING TEMP.	RES.______	SRA UP				
		SRA DN				
	TEMP.______	DIFF				
APPROX. + 2°F	RES.______	SRA UP				
		SRA DN				
	TEMP.______	DIFF				
APPROX - 2°F	RES.______	SRA UP				
		SRA DN				
	TEMP.______	DIFF				

FLOTATION TEMPERATURE ______ °F; ______ Ω

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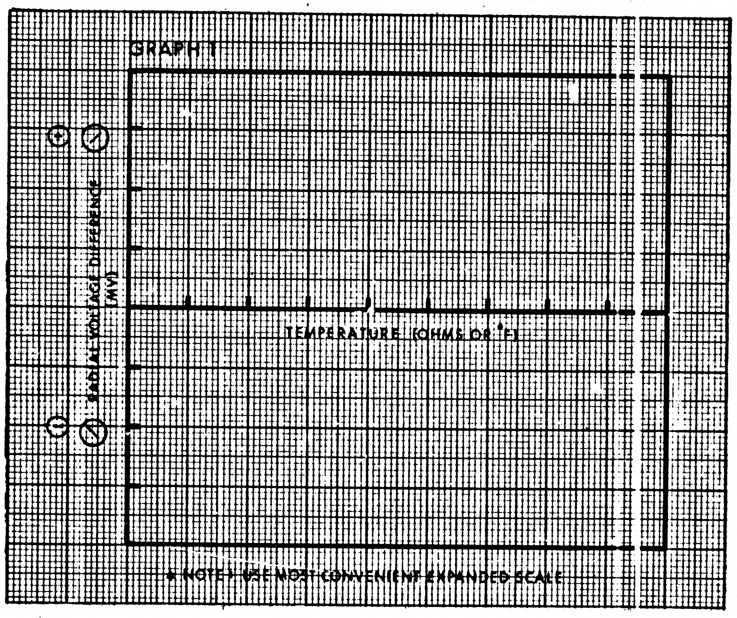

sheet (MC 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator or Cleveland Indiron should not exceed 20 microinches, and should not extend more than .050" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (MC 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150° ± 5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
Model 153-40 used with small jet spindles and Class XXX Master Gage Rings
Hand Lap - 3/8" dia. x 3" long - American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Co., Inc.
Zeiss Stereo Microscope or American Optical
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner
Cleveland Indiron

5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries inc.,
Sycamore, Illinois

6.0 'B' DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.976000 gage block and the Johansson Mikrokator S 510-E-8, measure accurately (to within 5 microinches) dimension 'B' and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment

C. E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per (MC 25-878).

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used. Insure that interference is reduced to a minimum by predenting the ball pockets. This should eliminate possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

---

measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture (D-95850). Rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\cos\beta = \frac{E}{d}\left[1 - 2\frac{N_e}{N_i}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on (MC 25-886.)

Equipment
Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension 'A' as recorded on bearing package by manufacturer, and dimension 'B' as measured in section 6, determine spacer thickness by using the following formula:

A = B + t-65 microinches
or t = A - B + 65 microinches

where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 20 microns minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE

9.2.1 Centrifuge retainer for 15 ±1minutes at 9000 ± 150 G's one side only.

9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.

9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 20 microns minimum.

9.2.4 Remove retainers from oven and weigh immediately.

9.2.5 Compute oil retention of each retainer as follows:

$$\%\ \text{retention} = \frac{W_1 - W_o}{W_0} \times 100$$

where W_0 = weight of dry retainer

W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.
If oil retention is outside specified retention range, retainers may be re-soaked in oil and/or recentrifuged varying the times to achieve the specified retention limits.

9.2.6 After retainers are impregnated, O.D. of retainer, pocket diameter and, pocket alignment shall meet tolerances shown on (Dwg. C-2021817).

9.2.7 Store retainers in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

9.2.8 General Notes:

9.2.8.1 Retainers should be handled with bone tweezers or gloves to minimize moisture absorption and contamination.

9.2.8.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.7 above.

9.2.8.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
A. Henry

DATE: 10-11-67

MC 25-890 REV A

SHEET 4
OF 4

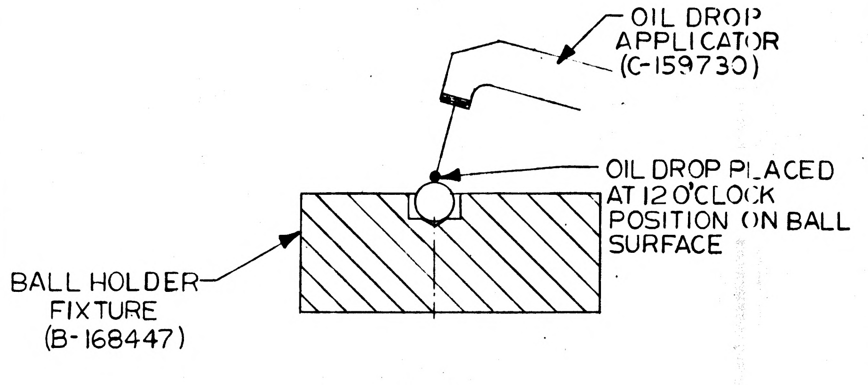
OIL DROP APPLICATOR (C-159730)
OIL DROP PLACED AT 12 O'CLOCK POSITION ON BALL SURFACE
BALL HOLDER FIXTURE (B-168447)

FIG 6

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ± 5°F and 20 microns minimum, outgas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for 18 hours minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6 above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies (2A3-10A187-1) or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ± 5°F allowing 15-20 minutes for temperature to stabilize.

10.3.1.2 Remove from oven and install assemblies into centrifuge plate (2A3 10C187-1), or equivalent, and spin for 10 minutes ± 1/2 minute at 4000 ± 100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Remove from centrifuge and blot retainer edges with lens paper. Place retainers in oven at 150° ± 5°F for 3 to 6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percentage (%) absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 After recording weight and percentage retention, place in pyrex dish using desiccants to minimize the humidity of the storage environment

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet can be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per (MC 25-878.)

11.3 Clean wheel inertia element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ± 5°F and evacuate for one hour minimum at 29.5" Hg vacuum maximum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Assemble retainers, balls and outer races as follows:

12.1 With fixture (A-118577) assembled, place outer race with stamped end up on shoulder of fixture (A-118579).

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture (A-118578).

12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer. Inspect carefully with 25x to 30x microscope for contaminants.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy (A-118577)

12.5.1.1 Fixture (A-118579)

12.5.1.2 Fixture (A-118578)

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture (A-88948.3) with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with stainless steel tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer (C-202670)* over the bearing and use fixtures (A-88948.1) and (A-88948.2) to press into the bore. The force necessary to push the bearing into the bore will be in the range of 2-5 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight. NOTE: Insure that all threads of 0-80 have been lapped prior to assembly.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Place corresponding end of shaft upward on shaft holding fixture ass'y (Dwg. 166042). Hold element with installed bearing and install on shaft. Using wheel holding fixture (Dwg. 166045) install on top of element. Invert entire fixture ass'y so that wheel holding fixture (Dwg. 166045) becomes the base and carefully remove shaft holding fixture (Dwg. 166042).

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture (A-88948.1) and (A-88948.2) to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements).

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen head screws .187 long. NOTE; Insure that all threads of 0-80 Allen head screws have been lapped to remove burrs and smooth down rough edges. Assemble protective cap (Dwg. 166037) before using Allen wrench to adjust 0-80 screws.

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Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without placing any preload on the bearings.

13.13 Inspect with microscope at 30X heads only of 0-80 screws for loose particles of metal.

13.14 Remove dust protector if necessary prior to shaft strain.

14. SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore, the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter (A-92246.1) to the #2 end with the flat end inward and tighten to a torque of 0.75 in. lb (strain gage measurements at MIT indicate that 0.75 in. lb of torque produces 76 microinches/inch shaft strain and a corresponding 65 microinches shaft deformation). The 65 microinches shaft deformation will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION (Preload Fixture D-92272)

15.1 Assemble shaft adapter (A-92278) to the #2 end of wheel.

15.2 Assemble shaft cap (A-92277) to the #1 end of wheel. In assembly of these adapters care should be taken so that the applied torque does not exceed 0.75 in. lb.

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15.3 Preheat wheel in oven at 150° ± 5° for 15 to 20 minutes. Remove wheel from oven and hand rotate shaft in one direction a sufficient number of times to prelubricate raceways and balls. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an additional 25-30 minutes and repeat prelubrication procedure. Once prelubrication is achieved, inspect bearings for contamination and repeat step 13.13

15.4 Allow wheel to return to room temperature and position wheel on top plate (C-94190). Assemble weight pan (A-92281) with a 1 lb. weight.

15.5 Carefully inspect clamping ring (C-94185) on top of wheel insuring that delrin washer (A-94186) contacts wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan (A-92281) to chain hanging from shaft adapter (A-92278).

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying a three pound load. Lift the weight, zero the meter, and then gently apply the three pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

Note: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap (A-92277). Maximum axial runout of shaft cap is 10 microinches with ±45° rotation.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft ±45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ±10 microinches the proper preload has been achieved. Unload bearings and repeat steps 15.8 thru 15.11 to ensure return to reference within the ±10 microinches. If repeatability is not achieved change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and record the displacement of the indicator from zero for each weight in (MC-811). These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on (MC-811).

15.14 Before preliminary dynamic balancing, position of cap, (Dwg. C-2021669) shall be checked with cap centering ring (A-92244). Remove socket head screws on number one end of wheel and replace with final 0-80 screws.* Inspect at 25x to 30x for possible contamination of bearings. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)

16.1 Attach thermocouple wire with calibrated Alnor meter to center of OD of stator housing.

*NOTE: All threads of 0-80 screws shall have been previously lapped.

Cover stator housing and entire rotor platform with heater blanket of chromalox 630-2, 115 volts, 25 watts (R62) or equivalent. Place wheel in oven to preheat for approximately 30 minutes minimum at 150°F and at the same time preheat the rotor platform until Alnor meter indicates 140°-145°F. Remove wheel from oven and place in dynamic balancer. Increase the gain on amplifier until wheel just starts to rotate, note the voltage, and back off immediately. This is the breakaway voltage. NOTE: If breakaway voltage exceeds 16.5 volts check for retainer rub, high preload, etc. Increase amplifier gain to 28 volts. The wheel will rotate at synchronous speed and temperature will increase. At this speed the rotor platform temperature should be reset to 140°-145°F as indicated by Alnor meter.

16.2 Dynamically balance the wheel until the residual unbalance is no greater than "0.10 dyne-cm at 12,000 rpm. Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with delrin caps, Dwg. No. B-166037 to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope after each increment of balance. Visually inspect under 25x to 30x for contamination or physical change in bearings. Remove any trace of contamination.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 Place in a suitable closed glass container the cycling container, 2A3-10B177.

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.
Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.
Alt. Cycle: 32°F to 180°F

Equipment

Cycling Container; Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

19.1 Remove wheel from the dynamometer and place it in stand (A-88948.3). Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten with 11 to 13 oz. in. of torque. Care should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per(MC 25-304) may be used as an alternative material to tack screw heads.

19.2 With a microscope examine the area around the screw head and wipe off off any excess Loctite. (Loctite will not cure if exposed to air).
Repeat this procedure to all 8 screws.

19.3 To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures (A-88948.3),(A-92244)
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant type A
   American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per(SCD 2021552)

20 DYNAMIC BALANCING (Final)

20.1 Place the wheel in oven to preheat for 30 minutes minimum at 150°F. Remove wheel from oven and place in dynamic balancer. With amplifier gain adjusted to 28 volts, check the final balance of the wheel and make necessary corrections to achieve maximum residual unbalance of 0.10 dyne-cm at 24,000 rpm.

NOTE: This check should be made with the wheel at operating temperature as follows:
The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.

2) Cover the stator housing and entire rotor platform with heater blanket chromalox 630-2,115 volts, 25 watts,(R62) or equivalent.

3) Run the wheel at synchronous speed until the Alnor meter indicates 140°-145°F.

Equipment

Micro Dynamic Balancer, Model K-1
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
  Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

21.2 Clean off with vacuum hose and repeat 21.1.

21.3 Record final weight of wheel on(MC 25-811)(MC 25-628) and(MC 25-605).

21.4 Place the wheel in a covered glass container and store in moisture free atmosphere.

Equipment

Zeiss Stereo Microscope } or Equivalent
Vacuum hose }

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure (MC 25-855)

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter (A-95721), firmly to the VS-10.

22.2 Thread lock-nut (A-92357) to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter (A-95721) very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut (A-92357) firmly against the bushing, using spanner wrench (A-92359).

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 25-50 mv. At this drive voltage the acceleration level of the float is less than 2 g's.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V.T.V.M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on(M.C. 811) within ± 0.25 microinch/lb.

22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on(MC — 811) insert wrench (A-92262) in the + SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench (A-92262), and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on(MC 25-811) insert wrench (A-92262), and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in(M.C. 25-605)

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 1.0 microinch/lb. If the term ΔC is greater than 1.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4° / min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in(MC — -811). If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

22.14 Using a spade oiler, or other suitable tool, apply LCA-9, (SCD 2021529) (MC 25-302) to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14. Replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on(MC 25-605)

22.19 Refer to(MC 25-855) for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder (2A3-10A180-1.2) with the Fenwal Thermistor probe into one of the IA balance ports.

23.2 Install the float into fixture (C-87364) and attach power and thermistor leads onto provided terminal strip.

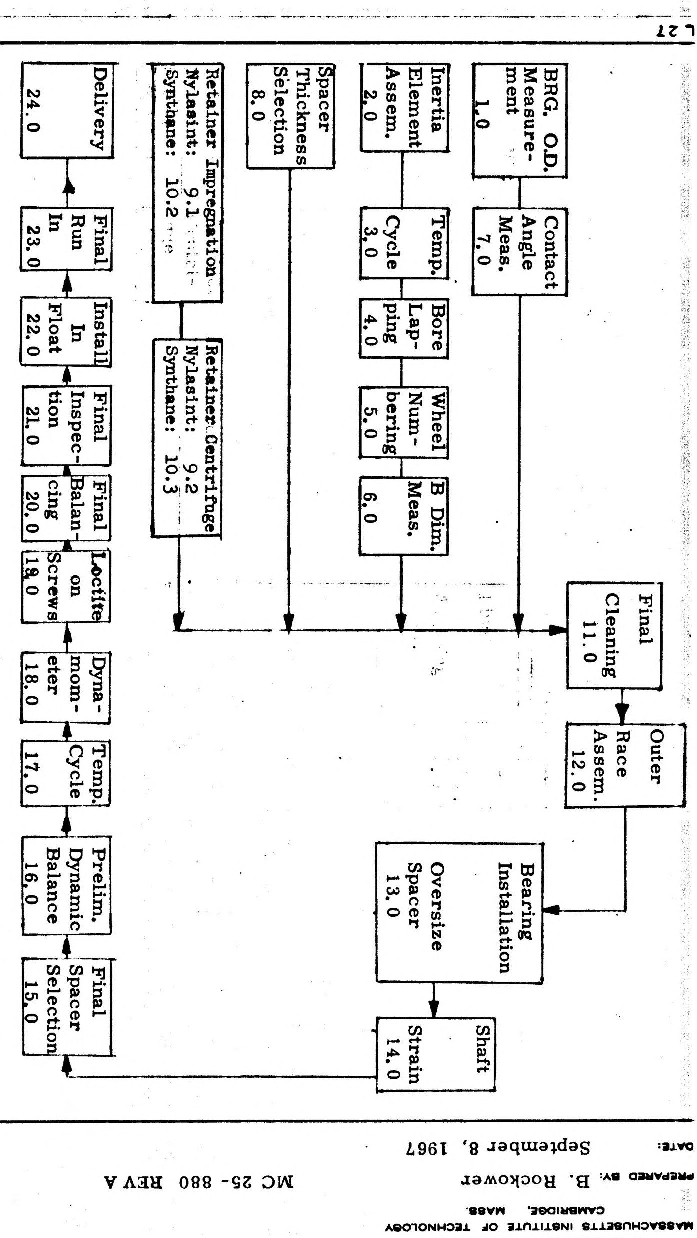
23.3 Install top plate (A-87364.1) on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 135°-140°F. With wheel at 135°-140°F turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per(MC 25-882)

24. DELIVERY

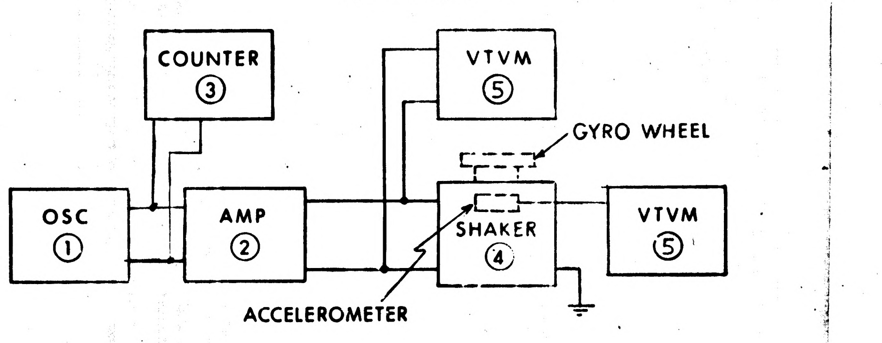
Continue float assembly per(MC 25-855)


IL 27
BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation
Nylasint: 9.1
Synthane: 10.2
Retainer Centrifuge
Nylasint: 9.2
Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation
Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Loctite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

Fig. 1

Compliance Checking Equipment
Apollo 2 Gyro


COUNTER ③
VTVM ⑤
GYRO WHEEL
OSC ①
AMP ②
SHAKER ④
VTVM ⑤
ACCELEROMETER

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H

Fig 2

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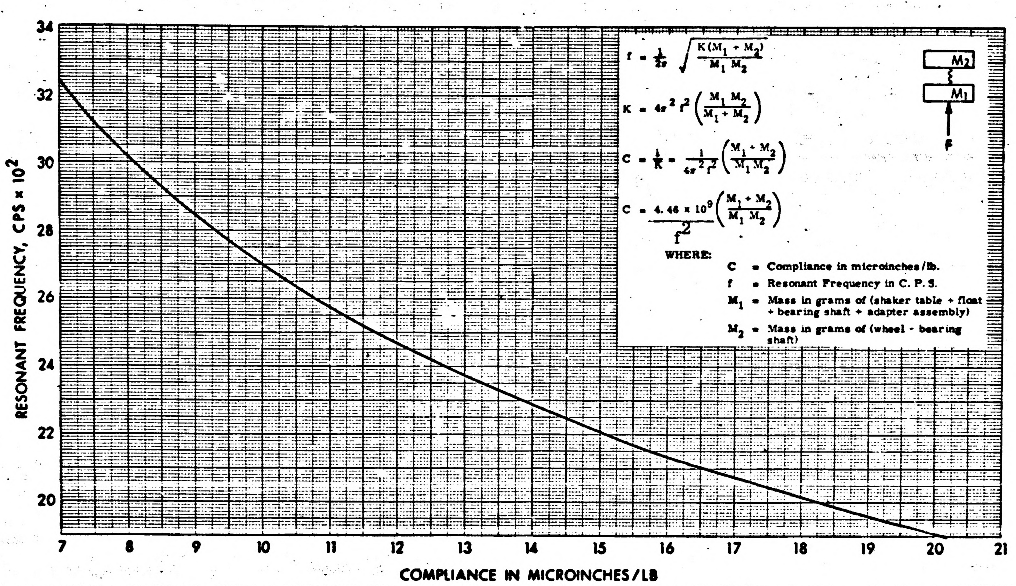
PREPARED BY B. Rockower

DATE: September 8, 1967

MC 25-880

SHEET 24 OF 24



$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.
f = Resonant Frequency in C. P. S.
M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)
M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

FIG 3

IL 27

74

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC 25-861

SHEET 1
OF 3

Rev A 10/27/64

ASSEMBLY PROCEDURE FOR MICROSYN APOLLO II IRIG

1.0 Coils

1.1 Assemble arbor A-104296 and coat with mold release. (DC 20 or equivalent)

1.2 Winding directions and number of turns are found on coil drawings.

1.3 Wind coil dry, except for layer of lens tissue painted with Epon 828 on double-wound coil assembly between windings.

1.4 Secure last lead.

1.5 Straighten leads and cut to length.

1.6 Impregnate coils per MC-25-501.

1.7 Remove coils from arbors.

1.8 Inspect per print.

1.9 From a group of at least 50 coils, select one to use as the standard coil. Measure the percent impedance deviations (plus and minus) of the primary and secondary of all other coils relative to the standard.

Compare coils in air at 10 kcps on a comparison bridge, selecting coils within a 1% span for a microsyn assembly (Fig 1).

1.91 The double-wound coil A and B windings should be checked and impedance differences plotted A vs. B. (Fig 2). Selection of eight coils should be made in a 1% square.

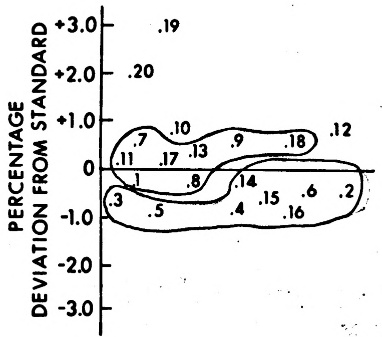

Fig 1

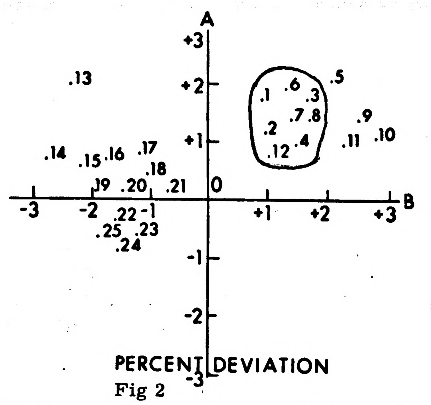

Fig 2

TDRR 14531 NOV 25 1964

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SHEET 2
OF 3

2.0 T. G. Microsyn Assembly 2021656

2.1 Wash stator core, printed circuit, and insulator by immersing in Methanol for 3 minutes and Freon for approximately 10 minutes in ultrasonic cleaner.

2.2 Bond insulator and printed circuit to Durafilm side of stator core with C-7. Use fixture C-127576.

2.3 Place Assy. in oven and cure at 150°F for 1 $\frac{1}{2}$ hours. 1/2.

2.4 Remove Assy. from fixture.

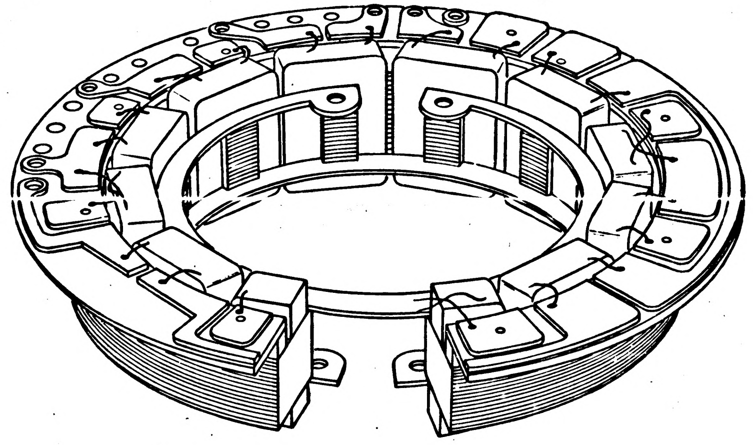
2.5 Place coils on stator core. Determine lead length and strip with X-Var.

2.6 Solder coil leads to pads using 60-40 solder and Kester 1571 flux.

2.7 Wash assembly in Methanol for 3 minutes and Freon for 10 minutes in ultrasonic cleaner.

2.8 Check continuity, polarity, and insulation test 250VDC, 500 megohms minimum.

2.9 Hold coils back with Durofilm coated Tru-Arc rings (A-82875). Perform insulation check again.



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PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

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SHEET 3
OF 3

2.10 Cement coils in position with C-7. Cover coil lead wires to pads with a thin coat of C-7.

2.11 Place assembly in oven and cure at 212°F for 1 hour.

2.12 Place tapered wooden sticks between coils 12 and 1 and between coils 1 and 2 to support reset coil while winding. Repeat for the rest of the reset coil winding. Wind reset coils.

2.13 Cut and form 0.005 Spaldo paper to fit between coils 2 and 3, 5 and 6, 8 and 9, and 1 and 12 to support winding.

2.14 Check for continuity, polarity, and grounds.

2.15 Remove one wooden stick at a time. Using thread, tie a slip knot around reset winding between coils where stick was removed and draw up to contain coil. Continue above procedure. Check 0.440 dimension. 0.440 dimension.

2.16 Solder reset leads to pads using 60-40 solder and Kester 1571 flux.

2.17 Wind bias coil on Pole #9 as shown in 2021656. Solder lead ends to pads using 60-40 and Kester 1571 flux.

2.18 With an eyedropper flow Methyl Cellosolve over reset and bias coil. (Methyl cellosolve is used for solvent bonding.)

A 2.19 Place assembly in oven and cure at 212°F for 1/2 hour.

2.20 Remove assembly from oven, let cool, remove thread (see 2.15) and Spaldo paper (see 2.13) then wash by immersing in Methanol for 3 minutes and freon for 10 minutes in Ultrasonic cleaner.

2.21 Check unit for continuity, size (0.440 Dim), and insulation test. 250 volts DC500 megohms.

A 2.22 Weigh out 25 Grams of Silastic #881 (Dow Corning) and 1.0 Grams of Activator #881 and mix thoroughly.

A 2.23 With a suitable applicator, coat the I. D. of the Microsyn Stack between the poles and cure for 2 hours at 160°F or overnight at room temperature.

2.24 Store unit carefully for future use.

3.0 S.G. Microsyn Assembly 2021664

Same as T.G. except omit steps 2.12 through 2.21.

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-891A
Release Date 7 MAR 69
Release Revision —
Class ______ ______ Release
TDRR 35342

IMPREGNATION OF APOLLO II (25 IRIG) END HOUSINGS

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
7 MAR 69	—	35942	INITIAL RELEASE		
6 Aug. 68	A	36022	2, 3	PRL	

TP#11938

This MC specification consists of page 1 to — and 1 to 4 inclusive.

IMPREGNATION OF APOLLO II (25 IRIG) END HOUSING

1.0 Scope

1.1 Purpose

This specification describes the process for impregnation of Apollo II (25 IRIG) end housings.

2.0 Applicable Documents

2.1 Effective Issues

The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, Military Standards and Specifications shall be the issue in effect on the date of Request for Proposal and Invitation to Bid.

Drawings

Apollo G & N

1010719	Epoxy Resin
1010720	Curing Agent for Epoxy Resin
1010721	Curing Agent for Epoxy Resin
1010722	Antifoam Agent

(Copies of specifications, standards, drawings, bulletins, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Conflicting Requirements

In event of a conflict between requirements, the following order of precedence shall apply. The contractor shall also notify MIT/IL Apollo Management of the conflict.

A. The Contract
B. This Specification
C. Documents in this Section

3.0 Requirements

3.1 Equipment

The following equipment is necessary in order to perform the impregnation process specified herein.

3.1.1 Vacuum Tank

The vacuum tank shall be capable of maintaining a vacuum of 20 microns maximum and a temperature of 160° ± 10°F. It shall have provisions for allowing the impregnant to enter the tank and cover the parts to be impregnated, while maintaining the vacuum.

3.1.2 Cylinder and Piston

The cylinder used to hold end housings shall be equipped with a piston capable of withstanding 2500 psi.

3.1.3 Platen Press

The platen press shall be equipped with heated (160° ± 10°F) platens and capable of generating a force sufficient, when used with the piston-cylinder combination, to obtain 2500 psi within the cylinder.

3.2 Process

Impregnation of Apollo II (25 IRIG) end housings shall be accomplished as follows:

a. End housings that have been finish ground and cleaned per ATP 2021500 MC 25-857 so that they are free of dirt and oil shall be placed in the presurrizing cylinder. This cylinder, less the piston, shall then be placed into the heated (160° ±10°F) vacuum tank. The tank vacuum shall be maintained at 20 microns for 24 hours while maintaining the temperature at 160° ± 10°F.

b. A mixture of 100 pbw (parts-by-weight) of epoxy resin (Drawing 1010719) and 102 pbw of methyl nadic anhydride (Drawing 1010720) shall be placed in a 160° ± 10°F oven for 1 hour minimum and 4 hours maximum.

c. 2 pbw of benzyldimethylamine accelerator (Drawing 1010721) shall be added to the heated mixture and mixed thoroughly. Violent mixing shall be avoided as it will tend to introduce air to the mixture. One drop of antifoam agent (Drawing 1010722) shall be added and the mixture degassed for five minutes at 200 to 300 microns while maintaining a temperature of 160° ± 10°F.

---

d. This impregnant shall be slowly poured into the receiver of the vacuum tank. The cock on the receiver shall be opened and the impregnant allowed to cover the end housings by at least 3/8 inch. Vacuum shall be held during this process. The cylinder containing parts and impregnant shall then be allowed to degas for 6 ± 1 minute. The vacuum shall be released and the cylinder removed from the vacuum chamber. Additional degassed impregnant may be added at this point to fill cylinder to a suitable level to accomodate the piston.

e. The cylinder and piston assembly shall be placed into the platen press with platen heated to 160° ± 10°F. A force shall be applied which is sufficient to create a 2500 ± 60 psi within the cylinder.

f. The applied force and the 160° ± 10°F temperature shall be maintained for 45 ± 3 minutes after which time the end housings shall be removed from the impregnant. All excess impregnant shall be cleaned off by wiping with Kimwipes followed by wiping with watch paper. Acid brush or Kimwipes dipped in methyl ethyl Ketone may be used to clean off housing and connector pins. Caution: Methyl Ethyl Ketone shall be kept from pole faces and potting material.

g. After all excess impregnant has been removed, the parts shall be placed in an oven heated to 160° ± 5°F. After 1/2 hour, the parts shall be removed to wipe off any excess impregnant and the parts then replaced in the oven. This process shall be repeated every 1/2 hour until no excess impregnant is observed after which time the parts shall be cured for 8 hours minimum at 160° ± 5°F.

h. The parts shall be cured an additional 24 hours minimum at 180°± 5°F.

4.0 Quality Assurance Provisions

4.1 General

The provisions of this section shall assure that the end housings have been properly impregnated.

4.2 Examination

The recorded data and computations shall be examined in order to determine compliance with the requirements of this specification.

4.3 Rejection and Rework

Processed items which do not meet all the requirements of this specification may be reworked in order to correct the defect. Items which cannot be reworked due to the nature of the defect shall be subject to rejection. Rejected items shall be salvaged to the greatest extent possible.

5.0 Preparation for Delivery

This section is not applicable to this specification.

6.0 Notes

None

NOTICE: When Apollo G & N drawings, specifications, or other data are used for any purpose, NASA thereby incurs no responsibility nor any obligation whatsoever; and the fact that NASA may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use, or sell any patented invention that may be in any way related thereto.

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PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964
MC25-862
SHEET 1
OF 3

ASSEMBLY PROCEDURE FOR SUSPENSION, APOLLO II IRIG

1.0 Core Winding Preparation

A 1.1 Assemble winding arbor B-82382 (2 parts) with suspension core -2021686. Be sure to assemble winding fixture so that winding arbor extension can be used if needed.

2.0 Suspension Core Winding

2.1 Suspension can be hand wound or machine wound.

A 2.2 Winding direction, number of turns per pole, type, and size wire are given on 2021657.

2.3 Coil pair ends shall come out on Small Dia. side of suspension core.

2.4 Strip coil lead ends approximately 1/2" from end.

2.5 With an ohmmeter check each coil pair for grounding to core upon completion of winding. Identify Pole #1.

2.6 Determine pole-pair ends by continuity method and twist individual coil pair ends together to keep separated.

2.7 Measure coil-pair resistances with a Wheatstone Bridge. The four Resistance readings shall have a spread of 5% max.

Rev A 10-30-64

3.0 Forming

A 3.1 Insert slot papers 2021584 in each slot. Use nonmetallic instrument for forming.

3.2 Trim slot papers to approximate length as shown.

3.3 Form coils by sliding forming fixtures over winding arbor until forming fixture ends are flush with winding arbor ends.

3.4 Most units do not require forming but it is a good idea to run through the steps anyway.

4.0 Lead out Wire Assembly

4.1 Slots where lead out wires are to be inserted require 2 slot papers. Follow same procedure as previously outlined.

4.2 Make lead out wire clearance hole between slot papers with a non-metallic instrument.

4.3 Strip lead out wires 1/8" back from end and tin (60-40 Solder Kester 1571 Flux). Push lead out wires up between slot papers until 1/2" is protruding above coil.

4.4 Strip and solder (60-40 Solder Kester Flux) coil end wires to appropriate lead out wires. Trim excess lead out wire for smooth joint.

4.5 Pull lead out wires back so that solder connection is below surface of coils.

4.6 Remove Winding Arbor.

4.7 Wash unit ultrasonicially in synthetic Methanol for approximately 1 minute to remove flux residue then wash ultrasonically in freon for approximately 10 minutes.

5.0 Preliminary electrical tests

A 5.1 Make polarity check per 2021657. Make insulation tests with 250V megohmmeter DC(500 megohns minimum).

6.0 Final Lead Out Wire Assembly

6.1 Apply C-7 to top and bottom of cell slot to secure the lead out wire.

A 6.2 Apply thin coating of C-7-9 on common coil lead that runs across top of other coils.

6.3 Cure Assembly for 2 1/2 hours at 180°F.

7.0 Prepot Electrical Tests

7.1 Perform Shorted turn test.

7.1.1. Connect and excite per Fig 1.

7.1.2 Series tune each of four coil pairs, recording V in and C at resonance.

7.1.3 The 4 V in readings shall be within 5% of one another and the capacitors spread shall be 5% maximum.

7.2 Check magnetic characteristics per MC 25-112.

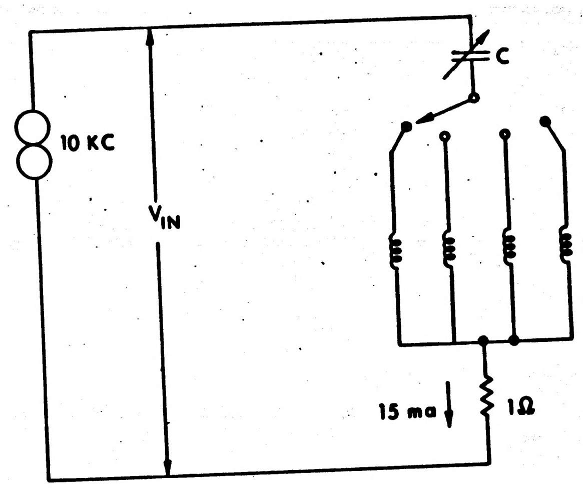


FIG. 1

APOLLO II IRIG Specification
MC 25 -882 A
Release Date ____________
Release Revision —
Class A Release
TDRR 35599

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 Feb 68	—	35599	INITIAL RELEASE		
8/21/68	A	36392	3, 11		

This MC specification consists of page 1 to____and 1 to 11 inclusive.

TP#11938

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per(MC 25-834)with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to(MC 25-889)for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm
n = Number of run-down time checks (no less than 8)
$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic power variations that are greater than 8 milliwatts. Figs. 1a, b, c represent acceptable power traces; 1b and 1c indicate acceptable periodic power variations that (are due to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 25 mw. The maximum allowable variation in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11	14
12	16
13	17
14	19
15	20
16	21
17	22
18	23
19-25	25

2.2.2 Provisionally Acceptable Power Trace

There are three categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 Power Level Wander

Fig. 2a is typical of a power trace exhibiting a disturbance of the power level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than twice during the 100 hour qualifying period as defined in section 1.2.

2.2.2.2 Test Equipment Influences

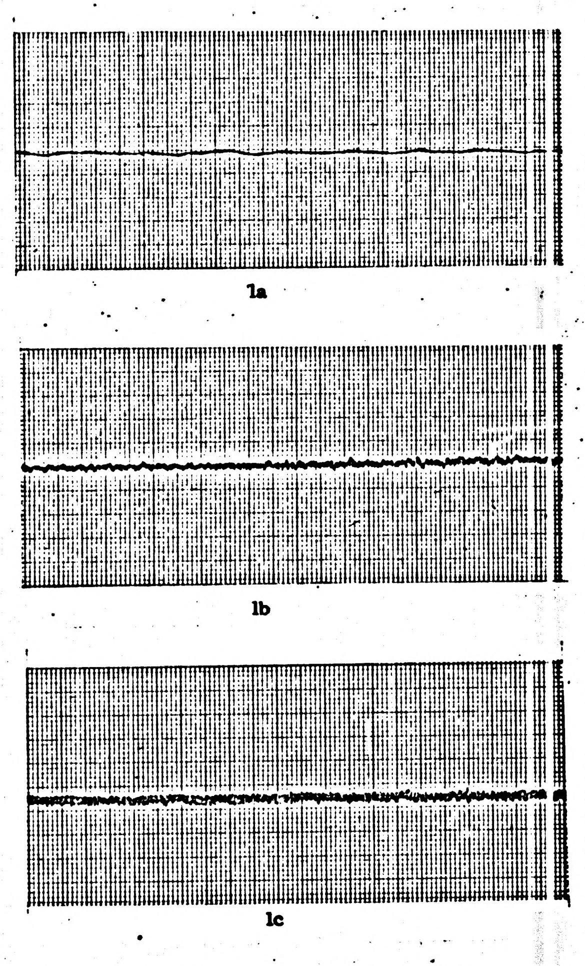
Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.3 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig. 3i).

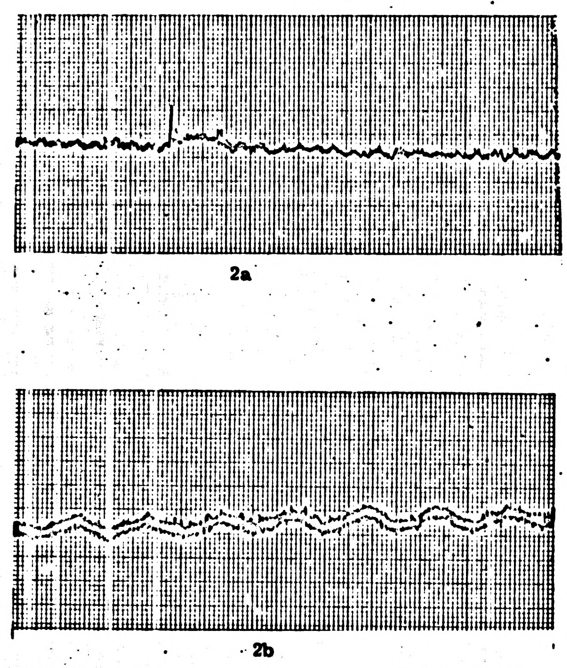

1a

1b

1c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sce ± 15%

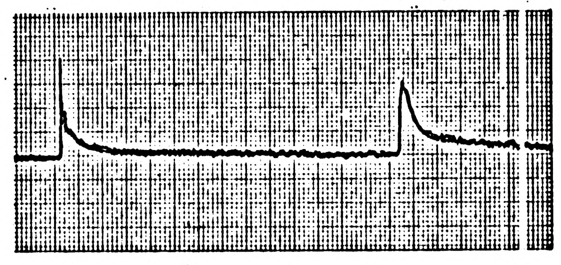
Fig. 1 Acceptable Power Traces


2a

2b

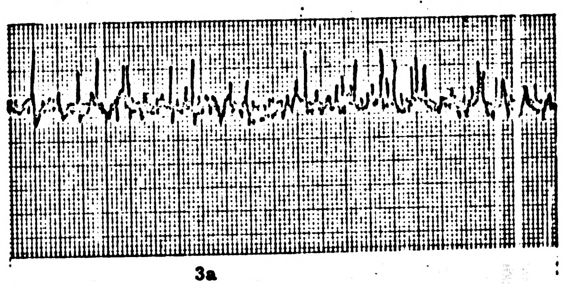
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

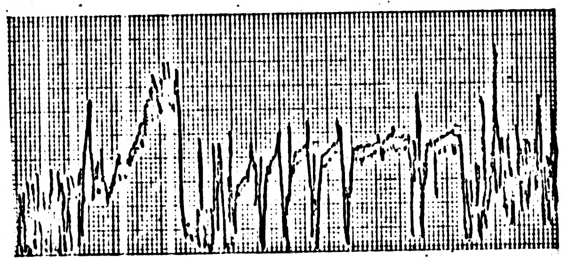
Fig. 2c Provisionally accepted power trace due to oil jog.


3a

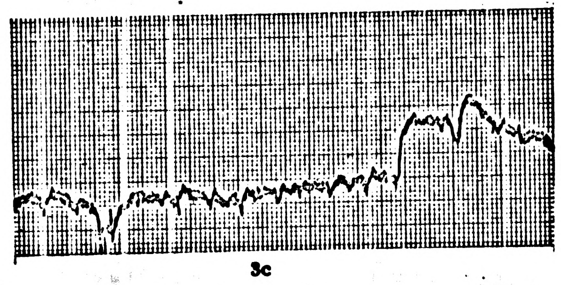
Probable Cause	
Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer super-imposed on a rough and irregular power trace.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

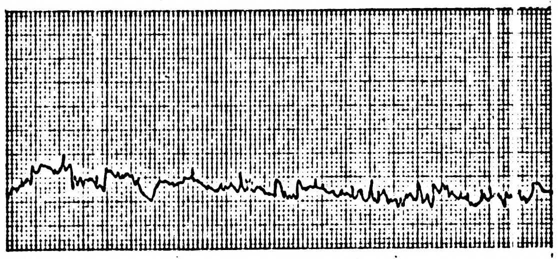
Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.


3c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces

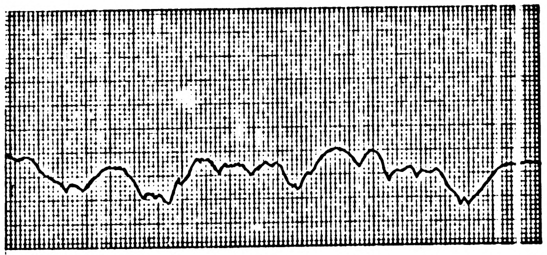


3d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced power variation.



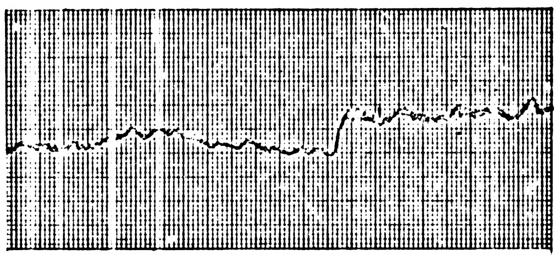
3e

Probable Cause
Varnish
Debris

A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

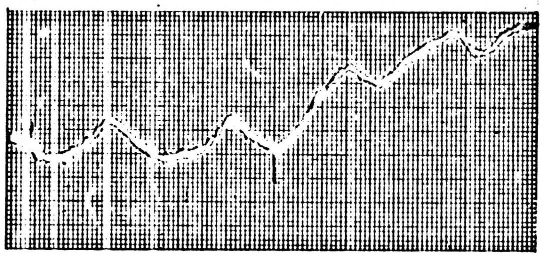


3f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



3g

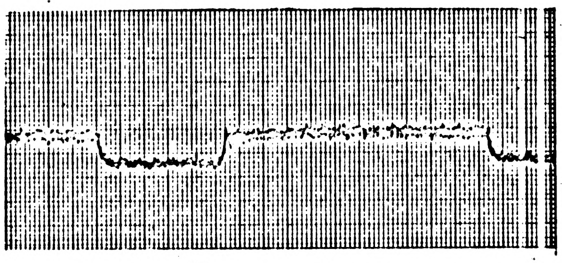
Probable Cause

Varnish

This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

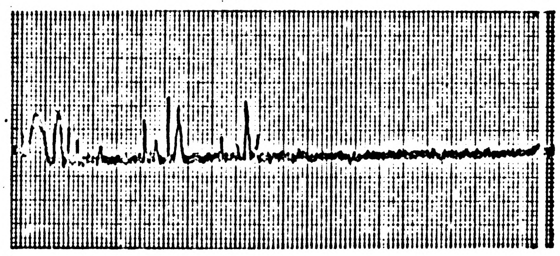


3h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light ot control the angular velocity o the ball group in one bearing.



3i

Probable Cause

Equipment

The power variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

TDRR 36392 AUG 6 1968

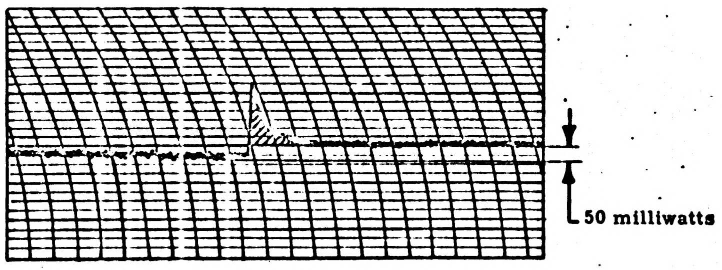


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.3.

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

1. Sub-Assemblies and Parts to be Demagnetized
   A. All magnetic parts prior to final assembly.
   B. Float Assembly, Dwg. 2021619.
   C. End housing assemblies, Dwg. 2021663 and 2021649.
2. Float Preparation
   A. Cementing the rotors to the stub shaft.
      1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance parts.
      2) Assemble the rotors to the float to insure proper seating.
      3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
      4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
      5) TG rotor should be aligned per MC 25-618 step A, 11.
      6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
      7) Place assemble in oven and cure for 1-1/2 hours minimum at 150°± 5°F.
      8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor rounouts and record.

      TG End ______________ TIR
      SG End ______________ TIR

      Maximum allowable runout on either end 0.0005 TIR.
3. Float Measurements
   A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

Rev A Revised and Rewritten 10-24-64

4. Flotation
   A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

      Weigh the float and record ____________ gm.
   B. Determine the neutral buoyancy, end for end and rotational balance as follows:
      1) Place the float in an oven at 140°F for about 15 minutes.
      2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
      3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
      4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

         Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

         Weight in air of solder on pivot at TG end ______________.

         Weight in air of solder on pivot at SG end ______________.

         Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

         Weight (in air) added to TG end ____________
         Material ____________
         Weight (in air) added to SG end ____________
         Material ____________
         Total float weight in air ____________
      5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

         Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.
   C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

NOTE: Plummets may be used to check fluid density while performing flotation.

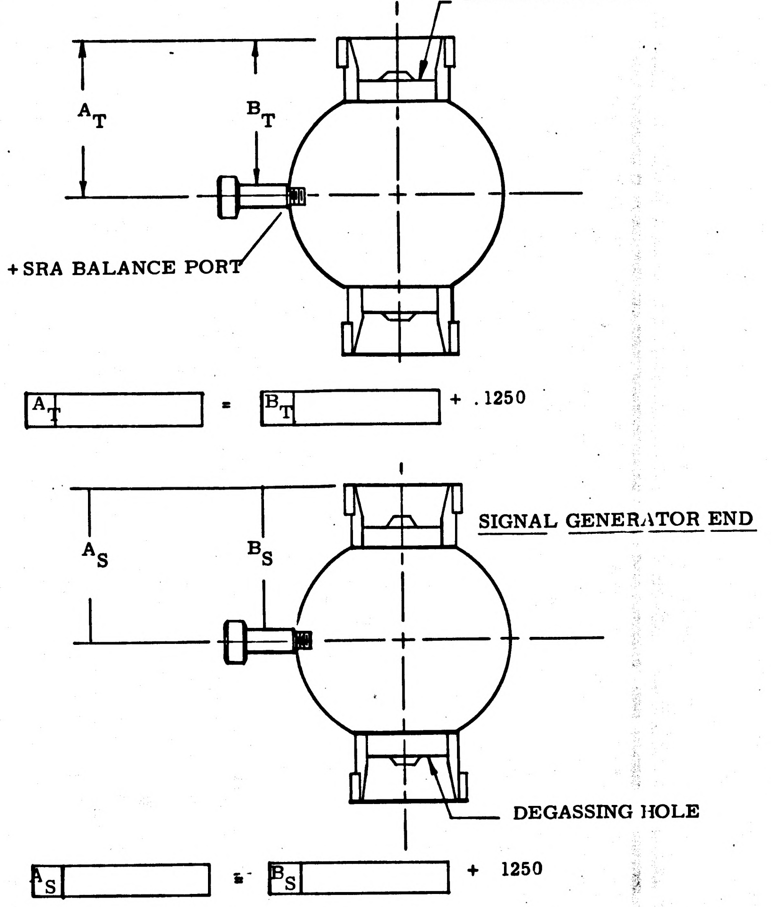
D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.

E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.

F. Leak check and record ______________ atm-cc/sec.
Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

FLOAT MEASUREMENTS

TORQUE GENERATOR END



5. Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.

B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly

A. End Cap Assembly

1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.

2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.

3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 0.50x10^{-8} atm-cc/sec.

4) Remove the sealing screw and ball (do not reuse the ball) and end cap parts.

B. Thermistor Installation

1) Procure thermistor per MC 25-801.

2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)

3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation

A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:

A. K&D #100 round nose for spreading.
B. K&D #106 flat for staking eyelet to counterbore.
C. K&D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.

F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kerter #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37-1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with trichloroethylene and a #2 artist brush. Finally clean joint with freon and artist brush.

E. Repeat A through D for the second damping block.

10. Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing

A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and #9. Place the spacer Z_s in the support block A-118435. Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

B. Carefully lower the float into the main housing, with the torque generator up, the B-facing the assembler and + SRA to the left.

See sheet #8 figure #2.

C. Insert the dummy stop pin A-92284 into the +SRA balance port, and secure it with a locking screw.

D. Insert the +IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer.

12. Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.

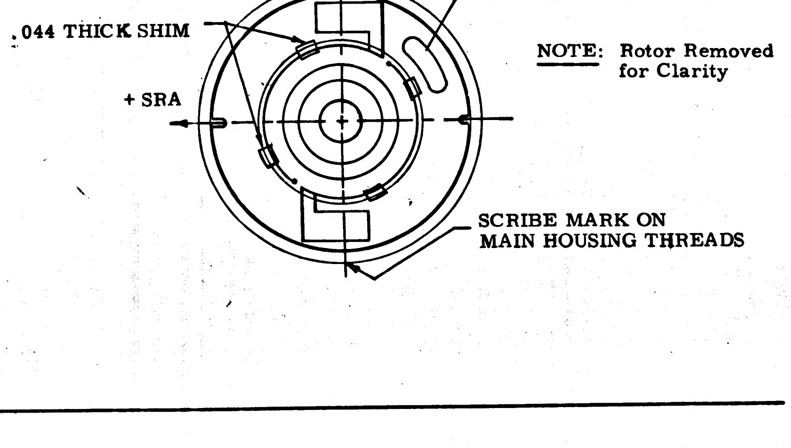
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

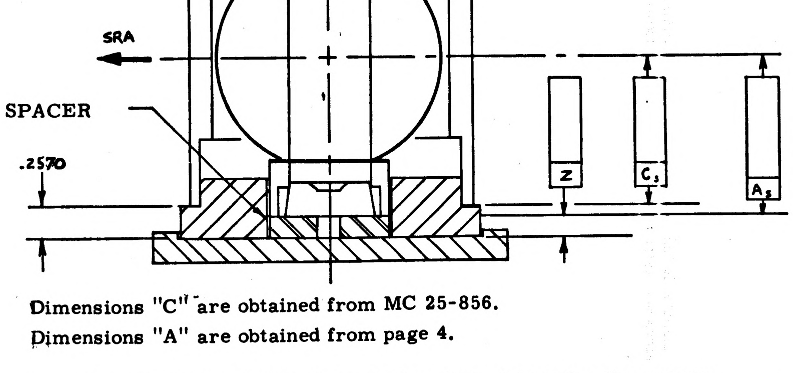
D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.


THERMISTOR CUTOUT
.044 THICK SHIM
NOTE: Rotor Removed for Clarity
+ SRA
SCRIBE MARK ON MAIN HOUSING THREADS

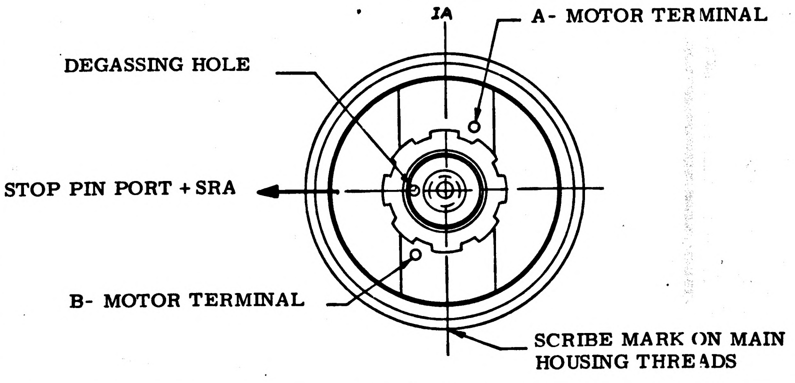


Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

$$Z_s = 0.2570 + \boxed{C_3 \qquad} - \boxed{A_s \qquad}$$

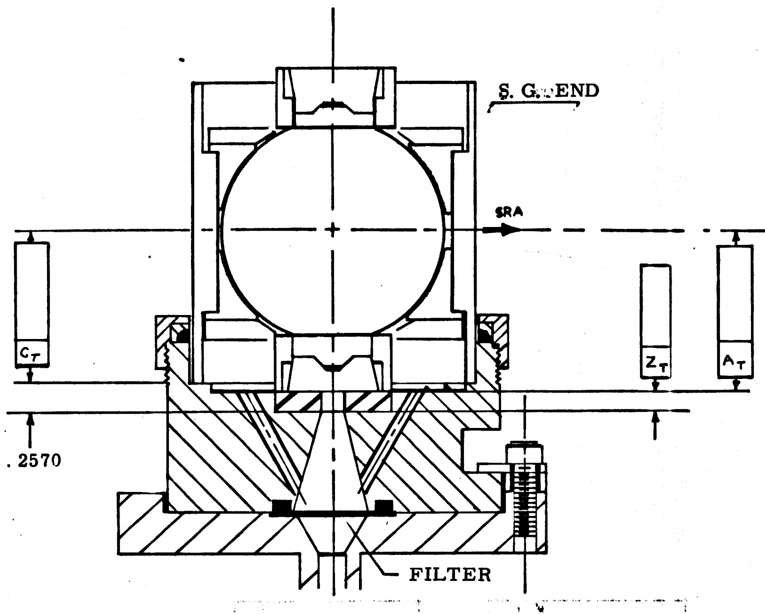


13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



$Z_T = 0.2570 + \boxed{C_T\quad} - \boxed{A_T\quad}$

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O.D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O.D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

H. Solder the flex leads to the float terminals as before.

14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 50 microinches.

E. Apply Damping Fluid (MC 25-612) sparingly to the pivot body and then wipe thoroughly with lens tissue. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #17.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut.

17. Dry Centering

A. Dry center the instrument as per MC 25-854.

18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 60 in-lbs. Invert unit and repeat above procedures.

19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page #13.

---

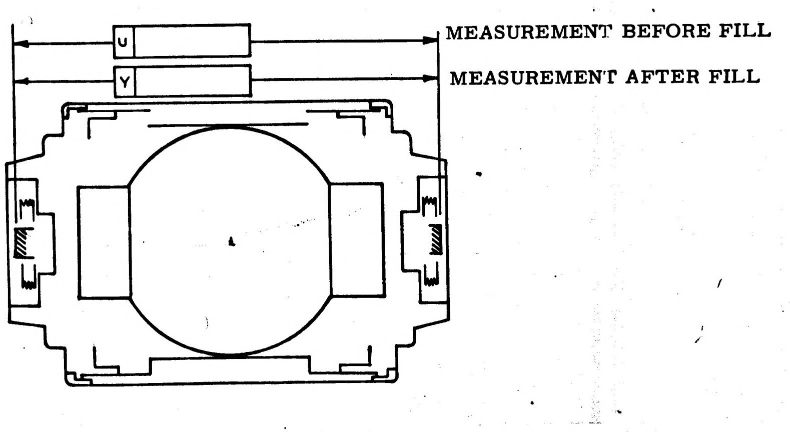
20. Bellows Measurement

A. Measure bellows overall length and record below.

B. Weigh the unit and record.

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



Weight of Unit Before Fill ------- Grams

Weight of Unit After Fill ------- Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding -------

Min. bellows extension before shrouding = 0.130" Total

Weight of Unit After Shrouding ------ Grams

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64
MC# 25-853
SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEAL'NG	AFTER FILLING
$P1_1$ TO $P2_{10}$ PRI.						T+ TO T COMM					
$S1_3$ HIGH TO $S1_2$ SEC						T- TO T COMM					
$S1_2$ TO SSQ1 SEC						$P2_{10}$ TO $P1_1$					
$S1_2$ TO SSQ2 SEC						R_2 TO R_1					
$S1_2$ TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
THER TO THER						THER TO THER					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					
MOTOR CIRCUIT											
A- TO A+											
B- TO B+											
A- TO B-											
A+ TO B+											

IL 27

Rev. A 11-9-64 Revised and Rewritten

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
TDRR 14363 NOV 18 1964
PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964
MC 25-854
SHEET 1 of 5

APOLLO II IRIG DRY CENTERING PROCEDURE

1. Preliminary

1.1 Mount unit in Fixture D-87262 with +SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Figure #1 and check continuity through cabling.

1.3 Heat unit to 135° ± 5°F and maintain temperature.

1.4 Excite gyro per Figure #1 at 10.0 volts ± 1%.

1.5 Center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position.

2. Angular Alignment of Microsyns

2.1 Rotate the gyro about OA from +SRA down to +SRA up and back to down. Observe radial signal relative phases. A phase reversal indicates radial freedom, which must be attained before continuing.

2.2 Drive the float electrically between angular stops by torquing per Figure #1 insert, and ensure that the +IA and +SRA balance paddles are rotationally centered in the 12-72 balance weights. Nominal torquing current required is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 87262.2 until the angular stop voltages are equal within 10 millivolts.

2.4 With the T. G. excited as a signal generator as in Figure #1, note the magnitude and phase of V_o. Rotate the T. G. end housing until V_o has the same relative phase and magnitude, within ±2mv, as in MC 25-860 Step 3.5.

2.5 Using an adjustable C- clamp as a tool, clamp the end housing tight to the main housing. The parts should bottom to give line-on-line fit when examined with an eye loupe.

2.6 Repeat Step 2.1 and note phase and magnitude of radial signals. The maximum acceptable centering ratio is 6:1.

3. Setting End Shake

3.1 With the unit in the OA vertical up position, adjust the T. G. pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 20±1 ma. Adjust the S. G. pivot, if necessary, to ensure that the float does not become locked between the pivots.

3.2 Use the axial sensitivity of 0.27 ma/0.0001 in. and retract the T. G. pivot 0.00075 inch (1/2 the total end shake) by monitoring the change in the T. G. suspension current.

3.3 Advance the S. G. pivot until it just bottoms.

3.4 Slowly rotate the gyro until the OA is vertical down.

3.5 Retract the S. G. pivot until the suspension currents are equal and then using the same calibration, retract the S. G. pivot .00075 inches by monitoring the change in the S. G. suspension current.
ALLOWABLE END SHAKE .0015 ± .0005

3.6 With the gyro in the OA vertical position, apply a very small amount of LCA-9 adhesive (MC 25-302) to the pivot and end housing at three points 120° apart. Cure per MC 25-302. Rotate to the S. G. up position and repeat the cementing procedure.

3.7 Remove the pivot adjustment fixtures.

---

4. Cementing Clamping Caps

4.1 Recheck angular stops and microsyn alignments, re-adjusting as necessary.

4.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

4.3 Coat the threads on the clamping cap with Epon 828 and assemble to the unit. Wipe off excess cement.

4.4 Check the angular centering and make any necessary adjustments before cement sets up. Keep the unit OA vertical for one-half hour with the cemented end up.

4.5 Repeat 4.2 and 4.3 for other end and cure at 137°F for one hour.

5. Final Alignment Checks

5.1 Repeat 2.1 recording magnitude and phase of the radial signals. Maximum acceptable centering ratio is 6:1.

5.2 Recheck microsyn alignments and end shake. Record end shake currents and S. G. stop voltages.

5.3 Refer to MC 25-853 for continuation of final assembly.

DATA SHEET

2.4 Information from MC 25-860, 3.5
E_o = __________ mv O phase
Measurements from 2.5
E_o = __________ mv O phase

5.1 SGX __________ TGX __________
SRA up
SGY __________ TGY __________
SGX __________ TGX __________
SRA down
SGY __________ TGY __________

Centering Radios
SX __________ TX __________
SY __________ TY __________

5.2 Final suspension currents
OA up
I_{ms} __________ ma
I_{mt} __________ ma
OA down
I_{ms} __________ ma
I_{mt} __________ ma
Cw Stop __________ mv
CCw Stop __________ mv

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-884
Release Date ________
Release Revision —
Class A Release
TDRR 35599

NYLASINT RETAINER PROCESSING SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval	
				MIT	NASA
ⓝ 13 Feb 68	—	35599	INITIAL RELEASE		
3-22-68	A	35932	Was 3 p's., Now 4. 1, 2, 3	PRK	1

This MC specification consists of page 1 to ____ and 1 to 4 inclusive.

TP#11938

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (Material per Dwg C-2021819) with V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg C-2021816. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in. hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 20X magnification. Repeat steps a, b, or c, if necessary.

---

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150°-160°F and 29 1/2in. hg. minimum

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0± .5 grams/minute at a line pressure of 80 psi approx. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time (Approx.)
Ball Pockets	2 min each pocket
Outer Diameter	2 min total
Edges	2 min each edge
Inner Diameter	20 sec total

Note: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period).

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° - 150° and 29 1/2 in. hg. minimum

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

c. Finally inspect retainer for absence of burrs, contamination, and damage under 20X magnification.

---

d. Holes from pull out of solid nylon inclusions will be permitted on the I.D. surfaces and side edges of the retainer. Pull out at the edges of the ball pockets surfaces which intersects the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. or O.D. surface and the ball pocket surface. The depth of blend may not exceed .010 into the ball pocket or the O.D. or I.D. surface. (See Fig. 1).

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material.
Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown to black) inclusions are acceptable only if they are below the retainer surface.

8. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

c. The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: R. Sheaff
J. Psyhogeos
DATE: July 3, 1962

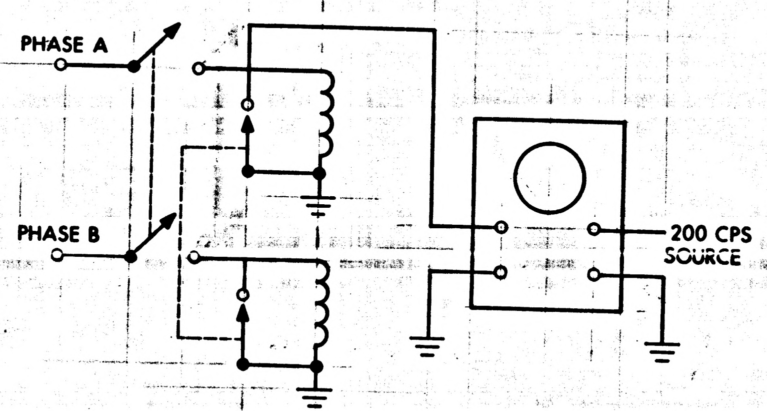
MC # 25-834

SHEET 1
OF 1

25 IRIG RUN DOWN TIME PROCEDURE

A With the wheel in sync at 28 V wheel excitation, open the line between the wheel power supply and the wheel windings. Immediately after opening (.2 to .5 seconds), place short circuit across Phase A and Phase B of the wheel for 5 seconds duration. Measure and record RDT from 24,000 to 6000 RPM and from 24,000 to 0 RPM.

Take one measurement only.



Rev. A 9/10/64

IL 27

INCHES
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CAMBRIDGE, MASS.

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964

MC 25-854

SHEET 5
OF 5

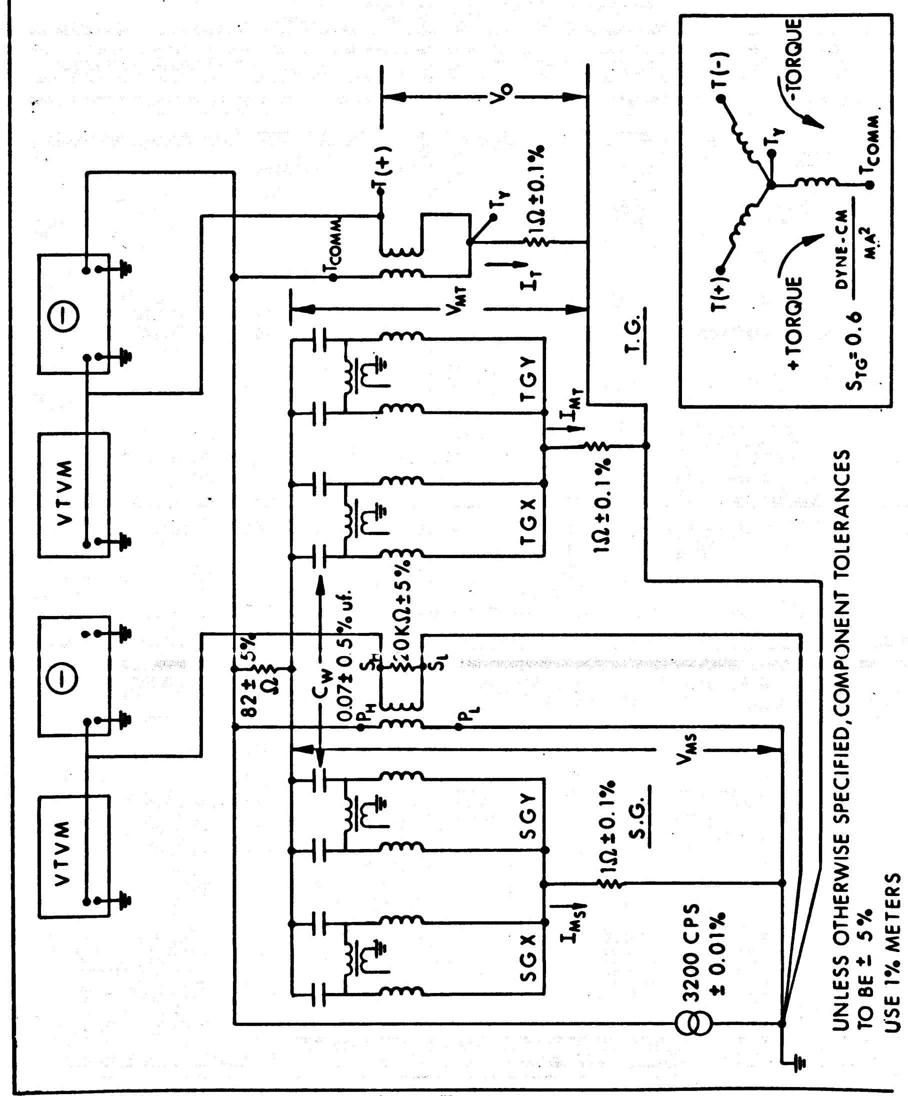
VTVM
VTVM
T_{COMM}
T(+)
T_V
V_O
1Ω ±0.1%
I_T
V_{MT}
T.G.
TGY
TGX
I_{MT}
1Ω ±0.1%
C_W 0.07 ± 0.5% uf.
82 ± 5% Ω
10KΩ ±5%
S_H
S_L
P_H
P_L
V_{MS}
SGY
SGX
1Ω ±0.1%
S.G.
I_{MS}
3200 CPS ± 0.01%
UNLESS OTHERWISE SPECIFIED, COMPONENT TOLERANCES TO BE ± 5%
USE 1% METERS
T(-)
-TORQUE
T_V
T_{COMM}
T(+)
+TORQUE
$S_{TG} = 0.6 \frac{DYNE\text{-}CM}{MA^2}$

Figure #1

TDRR 14363 NOV 18 1964

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CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 REV. A
SHEET 4
OF 4

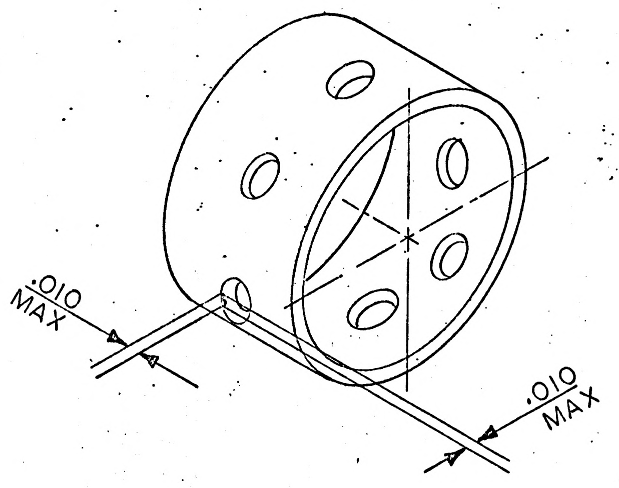

FIGURE I
BALL POCKET BLEND

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CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 1 OF 7

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.

1A. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA____________ -SRA____________

Record I. D of hemisphere shaft bore

+SRA____________ -SRA____________

Average Interference

+SRA____________ -SRA____________

2. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

A 3. Clean all the float parts in trichloroethylene followed by a freon rinse.

4. Weigh all the float parts and record information on sheet #6.

5. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Clean the parts as in step #3.

6. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

7. Measure and record the following:

A) O. D. of stator____________

B) I. D. of gimbal____________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".

C) Average interference____________(.0001-.0003)

Rev A 10-26-64

TDRR 14531 NOV 25 1964

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PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 2 OF 7

8. Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.

B. Place the bushing A-92287 into the pressure plate.

C. Assemble the motor stator to the pressure plate A-87423.

D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O. D.

F. Remove the gimbal and fixture base from the hot plate.

G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.

A H. Remove fixture and check centering of the stator in the gimbal. Check continuity.

A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

9. Weigh gimbal and record____________ gms.

A 10. Grind I. D. of motor stator as per drawing 2021625.

11. After grinding, perform visual inspection, and clean this assembly in varsol followed by a freon rinse. Check continuity.

12. Weigh gimbal and record____________gms.

A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

13. Power Lead Installation

A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F oven for 1/2 hour.

B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F.

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PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
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SHEET 3 OF 7

C. Repeat step "B" on oppostie end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F.

E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F.

14. Install .062 diamter ball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10 x 10^{-8} ATM cc/sec. Leak rate ____________

A 15. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt. cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10 x 10^{-8} ATM cc/sec.

Leak rate ____________

16. Remove the sealing screw and .062 diameter ball from the degassing hole.

17. Assembly of wheel to float

A. Thoroughly clean all float parts in filtered freon.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on thermostatically controlled hot plate set to 350°F + 15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from sealed plastic bag. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms.

A NOTE: Nylon gloves or finger cots to be worn when handling wheel.

18. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

19. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

20. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.

21. Heat the -SRA hemisphere as in "B" of step #17.

22. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

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DATE: Joseph Publicover
MC 25-855
SHEET 4 OF 7

23. Carefully assemble the wheel and +SRA hemsiphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

24. Balancing the float in Air

A A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

25. The float at this time is complete except for the rotors and balance weights. Weigh the float and record ____________ gms.

26. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T. I. R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 2.2.

27. Solder (4) 18" long lengths of #30 wire to the power leads using 60-40 Kester solder and 1571 flux.

28. Refer to MC 25-803 for instructions on setting the +SRA bushing.

29/ Remove the float from the run in fixture. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 180°F oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
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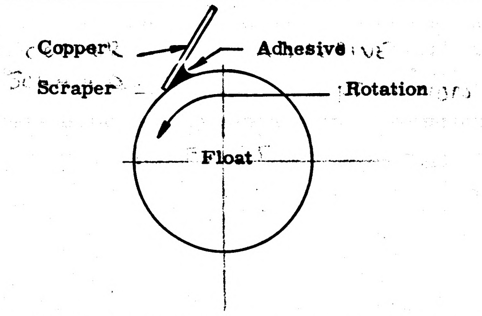

Examine the joint and add more adhesive if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 180°F max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 180°F.

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms

B. Place a 2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

C. Weigh the float and record ____________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. ________ gms.

31. Leak check and record ________________ atm-cc/sec.
Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min.

33. Leak check and record _____ ___________
Acceptable leak rate = 5×10^{-8} atm-cc/sec.

PREPARED BY: J. Publicover
DATE: February 10, 1964
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SHEET 6
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FLOAT WEIGHT RECORD

Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
A-87287	4	Power Lead-in		.092	
A-107251	8	Balance Weight (Final Rot. Adj.)		.740	
A-107252	4	Balance Weight Spring		.018	
B-87391	2	Centering Shim		.013	
B-87374	2	Bushing	1	1.676	
Comm'l.	1	#2-56 Sealing Screw		.037	
Comm'l.	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
C-87373	2	Hemisphere		14.701	
D-112977	1	Gimbal		26.051	
B-87289	1	Motor Stator (Finish Ground)		18.800	
A C-118575	2	Rotor Assy. *		32.968	
C-87341	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	18.702		
	As Req.	Adhesive for Sealing		.100	
A-84046	A Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.

PREPARED BY: Clifford J. Cormier
Joseph Publicover
DATE:
MC# 25-855
SHEET 7
OF 7

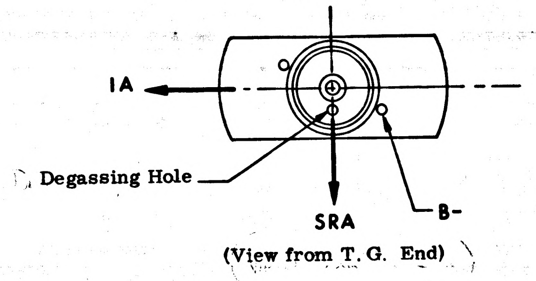

Fig. 1

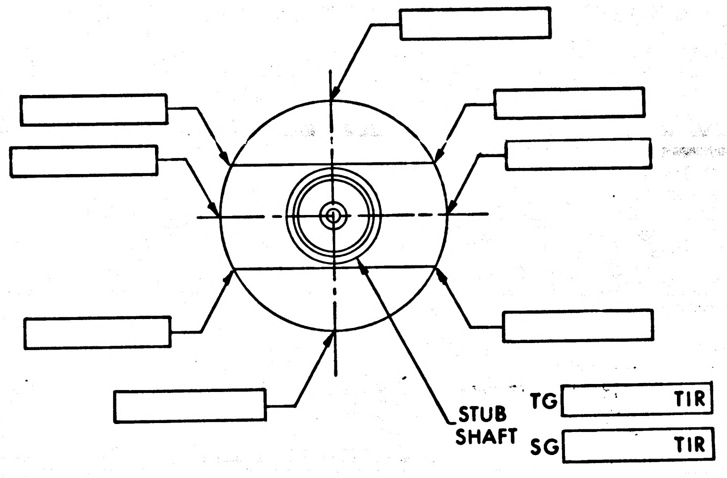

Fig. 2 Runout of float sphere to pivots.

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-887
Release Date ________
Release Revision —
Class A Release
TDRR 35599

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	R Booth	
8/1/68	A	36609	1,4		WLS

TP#11938

This MC specification consists of page 1
to ___ and 1 to 4 inclusive.

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

1. ENVIRONMENTAL CONDITIONS 40% maximum humidity
75° F + 2°F

2. CRITICAL AREAS--The critical areas shall be as shown in Figure 1.

3. ACCEPTANCE CRITERIA--The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination of 30 power magnification.

The critical areas of the races shall show a characteristic ground and polished, honed or lapped finish.

The critical areas shall be free from tool marks, chatter waves, grinding scratches, rust, stains, seams, inclusion, and pits, except as modified by the following:

a) A pit shall be any imperfection of a size such that the dimension across its major axis is greater than 0.0005 inch. Any imperfections less than this are acceptable.

b) No pit shall exceed 0.0012 inch across its major axis and no two pits shall be closer than 0.012 inch.

c) The maximum number of pits in the critical areas shall not exceed four per part.

d) Scratches, comet tails, grind tears and cuts running circumferentially in the critical ball track area shall not exceed 0.0012 inch in width, and no raised metal is acceptable.

11

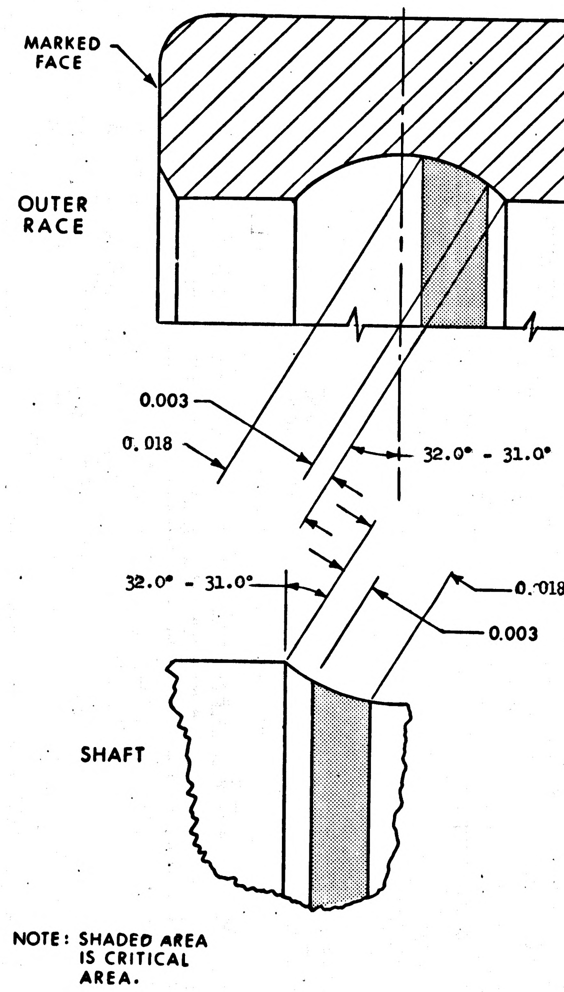

Fig. 1 Critical ball race areas.

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e) Scratches across the critical area shall not exceed 0.0005 inch in width.

f) No rust shall be present.

4. BALLS

a) The ball luster shall be very bright and the surface matte must be very fine. The following criteria shall determine the acceptability of the balls after microscopic examination under 10 power magnification.

(1) Defects---There shall be no noticeable defects as follows:

(a) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets in excess of .00012 inch width.

(b) Stains and rust - none

(c) Burrs - none

(d) Scratches - 0.0005 inch wide, showing no raised metal

(e) Flats - .0002 inch maximum width

5. Non critical Areas. - Non critical areas shall be all those not covered by the requirements of Paragraphs 2 and 3.

a) Acceptance Criteria. - The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination under 10 power magnification.

Defect	Ground Surfaces	Chamfers, Undercuts, Threads and Machined Bores
(1) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets	.0003 inch	None which affect dimensional tolerances.

A. END HOUSING ASSEMBLY, APOLLO II IRIG

I. Terminal Seal Assembly

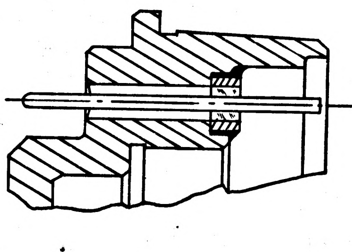
1. Clean the end housing and terminal seal ultrasonically in trichloroethylene, followed by a freon rinse.

A. 2. Leak check terminal seal using fixture B-123696 max leak rate 0.10×10^{-8} ATM-cc/sec. Leak rate ________

3. Place the end housing in the end housing holding fixture.

4. Place this assembly on a thermostatically controlled hot plate and heat the end housing to 160°F ±10°F for approximately ten (10) minutes.

5. With a watchmaker's spade oiler or some other suitable applicator, apply LCA-9 (MC 25-302) to the end housing as shown below.



Rev A 9-21-64

A. 6. Insert the terminal seal into the end housing.

7. Press the terminal seal into position with a small piece of sharpened pegwood to force the adhesive around the terminal and into the sixteen (16) 0.070" diameter holes in the end housing.

8. Center the terminal seal in the end housing using fixture C-127580.

9. Place the end housing holder and end housing in a 200°F oven and cure for two (2) hours.

10. After the initial two (2) hour cure, remove the assembly from the oven and cool to room temperature. As the 0.070" diameter holes are too deep to be completely filled with the adhesive, it is necessary to back-fill the pins. Feed C-7 adhesive into the holes and around the pins carefully. The adhesive should be flush or below flush with the bottom of the chamfer on the 0.070" diameter hole.

---

11. Repeat Step #9

12. Assemble the end housing to the leak check fixture A-87326 and leak check. If the leak rate is greater than 2×10^{-10} ATM-cc/sec; the assembly should be rejected.

13. Cycle the assembly from 0°F to + 180°F four times at a maximum rate of 3°/min.

14. Repeat Step #12.

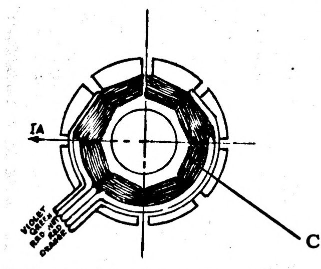
15. Mix 25 grams of Silastic RTV (Dow Corning) with 1.0 gram of Activator #881 and mix thoroughly. Coat the body of the terminal seal assembly and cure at 160°F for two (2) hours.

A II. Assembly of Inner Suspension to End Housing

1. Visually inspect the inner suspension 2021657 paying particular attention to solder connections and any loose wires that could be damaged during potting and grinding operations.

2. Perform resistance measurements and record the requested information on MC 25-858.

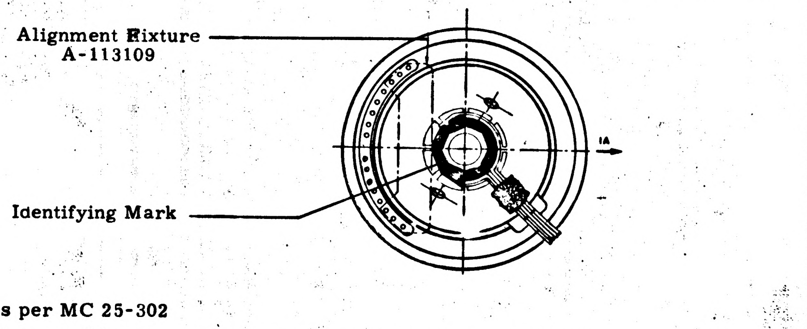
3. Shape and group the wires of the suspension as shown in the sketch below.



Coil with identifying mark.

A 4. Apply LCA-9 adhesive to the suspension seating shoulder of the end housing.

A 5. Assemble the inner suspension to the end housing, aligning the registration mark along the −IA axis using fixture A-113109. See sketch below.



A 6. Cure as per MC 25-302

7. Group the five (5) suspension wires as shown in the sketch of Note 5 and hold them in position with positioning fixture A-113235.

8. Bond the wires to the floor of the end housing using LCA-9 adhesive (See MC 25-302). Do not apply a heavy layer of adhesive over the wires. The outline of the wires should be just visible through the adhesive (0.035 max adhesive build-up). Cure the adhesive.

III. Assembly of the Microsyn to the End Housing

1. Perform a resistance check of the microsyn, and record on MC 25-858.

2. Check the microsyn for loose wires, loose or cold solder connections, solder build-up, burrs or cement build-up on the O.D. or windings.

3. Carefully fit the microsyn into the end housings aligning the 16 holes in the microsyn printed circuit with the pins and feeding the inner suspension wires through the slot in the printed circuit. Be sure the microsyn is seated. Perform an electrical check.

A 4. Solder the 7 short pins to the printed circuit using 60-40 solder and Kester 1571 flux. Carefully clean the solder joints with Kesters AP-20 or with an artists brush dipped in trichloretnylene and rinse with freon. Perform a resistance measurement and record.

IV. Assembly of Printed Circuit and Mumetal Shield

A 1. To insure solderability, remove surface film on buttons 2021655 either chemically or mechanically.

A 2. Tin both sides of the pads of printed circuit 2021652 (around the 0.062" diameter plated through holes). Clean with an artist's brush dipped in trichloroethylene and rinse with freon.

3. Apply a small amount of Kester 1571 flux to shoulder of the button. Position the buttons in the printed circuit and using a 37 1/2 watt iron, apply heat to the top of the button in order to form a solder fillet at the base. Clean as in step 2.

4. Cement the mumetal shield to the back of the printed circuit with Epon 828 adhesive and assemble to bonding fixture B-87377. Cure for 1 1/2 hours at 150°F.

5. Any excess adhesive on the O.D. of the assembly can be removed by using a medium grit emery paper. Rinse in freon.

V. Assembly of Printed Circuit to End Housing

1. Apply three tacks, at 120° intervals, of LCA-9 or Epon 828 adhesive to the end housing mounting shoulder.

2. Assemble the printed circuit to the end housing by feeding the 5 inner suspension wires through the slot and aligning the nine terminal pins with the holes of the printed circuit.

3. Solder the (9) terminal pins with 60-40 solder and Kester 1571 flux. Clean as in Section IV, 2.

NOTE: The height of all solder joints should be kept to a minimum to insure complete coverage during the potting operation.

4. Cut the (5) inner suspension wires so that the end of the wire will not reach the far end of the printed circuit pad. Strip the wire back as far as the slot in the printed circuit. Flare and flatten the wire strands and solder the wires to the printed circuit.

NOTE: Keep height of the bend of the wire and the 5 solder joints at a minimum. Clean as in Section IV, 2

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

(2)	Stains, rust	None	No rust, stains are acceptable.
(3)	Burrs,	None	None which affect dimensional tolerances.
(4)	Scratches	None which affect dimensional tolerances	None which affect dimensional tolerances
(5)	Flats	None which affect dimensional tolerances	None which affect dimensional tolerances

6. Contact angle determination - All necessary components of the contact angle shall be measured in accordance with the following formula to determine the contact angle:

$$\text{Cosine } \beta_o = \frac{E}{d}\left[1 - \left(\frac{2N_E}{N_i}\right)\right]$$

where E = pitch diameter of 0.249450(print nominal value)
d = average ball diameter of row (vendor supplied information)
N_E = number of revolutions of the retainer
N_i = Number of revolutions of the inner race
β_o = contact angle

PREPARED BY: David N. Kupelian
DATE: February 25, 1964
MC 25-857
SHEET 5
OF 5

VI. **Microsyn Stator Potting**

1. Refer to MC 25-507 for potting procedure. Follow MC 25-858 for the post cure and temperature cycling procedure.
2. Leak check the potted assembly using fixture A-87328. Maximum acceptable leak rate is 0.5 x 10^{-8} atm-cc/sec.

VII. **Microsyn Grinding**

A

1. Place a terminal pin protector A-109464 over the pins. Finish grind per drawings 2021649 and 2021663.
2. After the grinding operation, thoroughly clean the end housing assembly with an acid brush while immersed in warm varsol. Follow with a freon rinse.
3. Perform an electrical check and record on MC 25-858. Leak check. Maximum acceptable leak rate is 0.5 x 10^{-8} atm-cc/sec.

VIII. **Pivot Bore Measurements**

1. Using ball gages (A-122143) determine the pivot bore size and record __________.

IX. **End Housings are ready for testing per MC's 25-859, 25-860 and 25-866.**

M 1097

APOLLO II IRIG Specification
MC 25-878
Release Date ________
Release Revision —
Class A Release
TDRR 35599

CLEANING SPECIFICATION, BEARINGS, 52100 STEEL,

APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		
4/2/68	A	36623	1		—

TP#11938

This MC specification consists of page i to____and 1 to 1 inclusive.

M 1097

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: April 2, 1968
MC 25-878 Rev A
SHEET 1
OF ____

CLEANING SPECIFICATION, BEARING 52100 STEEL

1.0 Scope

1.1 This specification covers the cleaning procedure for removal of packing oil Teresso V-79 or any other contamination that maybe visually observed. on all outer races, balls and shafts before assembly as a unit bearing.

1.2 Equipment

Ultrasonic Cleaner

Beaker

Demagnetizer - Ideal Industries or equivalent
Sycamore, Illinois
Product No 13-011
115 volts, 50-60 cycles, 2 amps

Microscope

2.0 Cleaning Procedure

2.1 Clean metal parts ultrasonically for five minutes in toluene to remove [illegible] packing oil Teresso V-79 oil. [illegible]ze by passing beaker over demagnetizer 2 to 3 times. Remove parts from beaker and vacuum dry. Repeat this procedure once. NOTE: When vacuum drying, the solvent should be removed instantaneously so as to minimize possible formation of residual films.

2.2 Repeat para. 2.1 using trichloroethylene instead of toluene.

2.3 If visible oil film or other foreign matter cannot be removed by the above procedure, a non silicone based lens tissue may be used to remove the excess oil or foreign matter. Then repeat the cleaning procedure of para. 2.1 and 2.2.

2.4 Visually inspect all parts under a microscope at 30X. If parts are not suitable cleaned, the above cleaning procedure is repeated.

M 1097

APOLLO II IRIG Specification
MC 25-878
Release Date ______
Release Revision —
Class A Release
TDRR 35599

CLEANING SPECIFICATION, BEARINGS, 52100 STEEL,

APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 69	—	35599	INITIAL RELEASE		
4/2/68	A	36623	1		—

TP# 11938

This MC specification consists of page 1 to ___ and 1 to 1 inclusive.

3

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M 1097

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE. MASS.

PREPARED BY: B. Rockower
DATE: April 2, 1968

MC 25-878 Rev A

SHEET 1
OF ______

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115 volts, 50-60 cycles, 2 amps

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2.4 Visually inspect all parts under a microscope at 30X. If parts are not suitable cleaned, the above cleaning procedure is repeated.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

MC 25-859

SHEET 1
OF 2

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

Rev. A 11/9/64

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5%F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Figure 1

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1° and I_m and I_m - 83 ± 6 ma.

A 2.5 Disable SG primary and measure suspension reaction torque. Record. Limit is 0 ± 0.3 dyne-cm.

3.0 Signal Generator

3.1 Reconnect per Fig. 1.

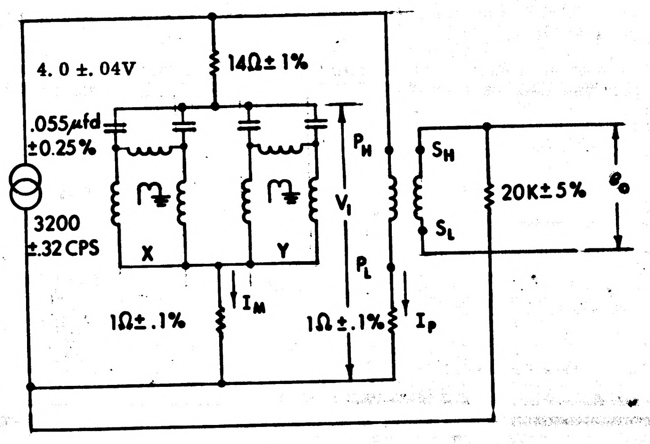
A 3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating and recording the angular sensitivity and relative phase of E_o vs V_{in}.

TDRR 14531 NOV 25 1964

3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.

A



No connections shall be made to quadrature or center tap tap terminals.

Fig. 1

APOLLO II IRIG Specification
MC 25-880
Release Date 8 FEB 68
Release Revision —
Class A Release
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	~~NASA~~
8 FEB 68	—	35585	INITIAL RELEASE	R Booth 2-7-68	—
8/1/68	A	36624	All except 8, 20, 24.	B Rockower 9-17	—
1/21/69	B	37228	20	MGM EA	WLS

TP#11938

This MC specification consists of page 1 to___and 1 to 24 inclusive.

Sheet 1 of 24

MC 25-880 REV A

APOLLO II WHEEL PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo II wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer (C-2021816) shall be packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per (MC 25-878). Check and inspect the bearing surfaces. No defects will be accepted on balls and critical areas of inner and outer races as defined by fig. 1 (MC 25-887) (e.g., corrosion, brinelling, burrs, stains, gage marks, raised metal, tears, cuts, scratches, stringers, nicks, dents, digs, gouges, comets, pits, and inclusions). Check for oil wettability per (MC 25-890).

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurements. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurements are made and record this information together with the average O.D. measurement on (MC 25-886). Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para 7.

1.5 Reclean the outer race per (MC 25-878) as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. The oil shall be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
Quick Seal type 150 Natl. Inst. Co., Baltimore, Maryland
Master Gage Plugs, Class XXX (.180000-.180020)
Sheffield Air Ring with two small jets for measuring the (.180000-.180030)diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring(.3748-.3749)diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749, .3750, 3751)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2.0 INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC. 25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture(B-87392).

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F, immerse wheel hub into liquid nitrogen until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps 2.6 through 2.8.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve(A-87392.5) and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press
Simpson Model 388 thermocouple indicator or equivalent.

3.0 TEMPERATURE CYCLING

3.1 Place in a suitable closed glass container. foil.

3.2 Place in the cycling container, (2A3-10B177) Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and + 200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber
Reynolds Aluminum Foil

4.0 LAPPING BEARING BORES

NOTE: Insure that all finished 0-80 tapped holes of hub element have been lapped.

4.1 Measure the lapping room temperature and using the wheel assembly data

sheet (MC 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator or Cleveland Indiron should not exceed 20 microinches, and should not extend more than .050" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (MC 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150° ± 5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
    Model 153-40 used with small jet spindles and Class XXX
    Master Gage Rings
Hand Lap-3/8" dia. x 3" long-American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Olive oil or
Mobil Velocite E oil - Soconv Mobil Co., Inc.
Zeiss Stereo Microscope or American Optical
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner
Cleveland Indiron

5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).
Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment
Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries inc.,
Sycamore, Illinois

6.0 'B'DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.976000 gage block and the Johansson Mikrokator S 510- E-8, measure accurately (to within 5 microinches) dimension'B' and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment
C. E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per(MC 25-878).

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used. Insure that interference is reduced to a minimum by predenting the ball pockets, This should eliminate possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

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measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture(D-95850). Rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\cos\beta = \frac{E}{d}\left[1 - 2\frac{N_e}{N_i}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on (MC 25-886.)

Equipment
Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension'A'as recorded on bearing package by manufacturer, and dimension'B'as measured in section 6, determine spacer thickness by using the following formula:
A = B + t-65 microinches
or t = A - B + 65 microinches
where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 20 microns minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE
9.2.1 Centrifuge retainer for 15 ±1minutes at 9000 ± 150 G's one side only.
9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.
9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 20 microns minimum.
9.2.4 Remove retainers from oven and weigh immediately.
9.2.5 Compute oil retention of each retainer as follows:

$$\%\ \text{retention} = \frac{W_1 - W_o}{W_0} \times 100$$

where W_0 = weight of dry retainer

W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.
If oil retention is outside specified retention range, retainers may be re-soaked in oil and/or recentrifuged varying the times to achieve the specified retention limits.

9.2.6 After retainers are impregnated, O.D. of retainer, pocket diameter and, pocket alignment shall meet tolerances shown on (Dwg. C-2021817).

9.2.7 Store retainers in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

9.2.8 General Notes:

9.2.8.1 Retainers should be handled with bone tweezers or gloves to minimize moisture absorption and contamination.

9.2.8.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.7 above.

9.2.8.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ± 5°F and 20 microns minimum, outgas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for 18 hours minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6 above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies (2A3-10A187-1) or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ± 5°F allowing 15-20 minutes for temperature to stabilize.

10.3.1.2 Remove from oven and install assemblies into centrifuge plate (2A3-10C187-1), or equivalent, and spin for 10 minutes ± 1/2 minute at 4000 ± 100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Remove from centrifuge and blot retainer edges with lens paper. Place retainers in oven at 150° ± 5°F for 3 to 6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percentage (%) absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 After recording weight and percentage retention, place in pyrex dish using desiccants to minimize the humidity of the storage environment

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet can be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per (MC 25-878.)

11.3 Clean wheel inertia element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ± 5°F and evacuate for one hour minimum at 29.5" Hg vacuum maximum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Assemble retainers, balls and outer races as follows:

12.1 With fixture (A-118577) assembled, place outer race with stamped end up on shoulder of fixture (A-118579).

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture (A-118578).

12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer. Inspect carefully with 25x to 30x microscope for contaminants.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy (A-118577)

12.5.1.1 Fixture (A-118579)

12.5.1.2 Fixture (A-118578)

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture (A-88948.3) with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with stainless steel tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer (C-202670)* over the bearing and use fixtures (A-88948.1) and (A-88948.2) to press into the bore. The force necessary to push the bearing into the bore will be in the range of 2-5 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight. NOTE: Insure that all threads of 0-80 have been lapped prior to assembly. [illegible] Co. prior to assembly.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Place corresponding end of shaft upward on shaft holding fixture ass'y (Dwg. 166042). Hold element with installed bearing and install on shaft. Using wheel holding fixture (Dwg. 166045) install on top of element. Invert entire fixture ass'y so that wheel holding fixture (Dwg. 166045) becomes the base and carefully remove shaft holding fixture (Dwg. 166042). this assembly [illegible]

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture (A-88948.1) and (A-88948.2) to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements).

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen head screws .187 long. NOTE; Insure that all threads of 0-80 Allen head screws have been lapped to remove burrs and smooth down rough edges. Assemble protective cap (Dwg. 166037) before using Allen wrench to adjust 0-80 screws. [illegible]

6201

Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without placing any preload on the bearings.

13.13 Inspect with microscope at 30X heads only of 0-80 screws for loose particles of metal.

13.14 Remove dust protector if necessary prior to shaft strain.

14. SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter (A-92246.1) to the #2 end with the flat end inward and tighten to a torque of 0.75 in. lb (strain gage measurements at MIT indicate that 0.75 in. lb of torque produces 76 microinches/inch shaft strain and a corresponding 65 microinches shaft deformation). The 65 microinches shaft deformation will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION (Preload Fixture D-92272)

15.1 Assemble shaft adapter (A-92278) to the #2 end of wheel.

15.2 Assemble shaft cap (A-92277) to the #1 end of wheel. In assembly of these adapters care should be taken so that the applied torque does not exceed 0.75 in. lb.

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15.3 Preheat wheel in oven at 150° ± 5° for 15 to 20 minutes. Remove wheel from oven and hand rotate shaft in one direction a sufficient number of times to prelubricate raceways and balls. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an additional 25-30 minutes and repeat prelubrication procedure. Once prelubrication is achieved, inspect bearings for contamination and repeat step 13.13

15.4 Allow wheel to return to room temperature and position wheel on top plate (C-94190). Assemble weight pan (A-92281) with a 1 lb. weight.

15.5 Carefully inspect clamping ring (C-94185) on top of wheel insuring that delrin washer (A-94186) contacts wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan (A-92281) to chain hanging from shaft adapter (A-92278).

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying a three pound load. Lift the weight, zero the meter, and then gently apply the three pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

Note: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap (A-92277). Maximum axial runout of shaft cap is 10 microinches with ±45° rotation.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

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Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft ±45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ±10 microinches the proper preload has been achieved. Unload bearings and repeat steps 15.8 thru 15.11 to ensure return to reference within the ±10 microinches. If repeatability is not achieved change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and record the displacement of the indicator from zero for each weight in (MC-811). These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on (MC-811).

15.14 Before preliminary dynamic balancing, position of cap, (Dwg. C-2021669) shall be checked with cap centering ring (A-92244). Remove socket head screws on number one end of wheel and replace with final 0-80 screws.* Inspect at 25x to 30x for possible contamination of bearings. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)

16.1 Attach thermocouple wire with calibrated Alnor meter to center of OD of stator housing.

*NOTE: All threads of 0-80 screws shall have been previously lapped. with lapping compound [illegible]-1200-US Products Co.

Cover stator housing and entire rotor platform with heater blanket of of chromalox 630-2, 115 volts, 25 watts (R62) or equivalent. Place wheel in oven to preheat for approximately 30 minutes minimum at 150°F and at the same time preheat the rotor platform until Alnor meter indicates 140°-145°F. Remove wheel from oven and place in dynamic balancer. Increase the gain on amplifier until wheel just starts to rotate, note the voltage, and back off immediately. This is the breakaway voltage. NOTE: If breakaway voltage exceeds 16.5 volts check for retainer rub, high preload, etc. Increase amplifier gain to 28 volts. The wheel will rotate at synchronous speed and temperature will increase. At this speed the rotor platform temperature should be reset to 140°-145°F as indicated by Alnor meter.

16.2 Dynamically balance the wheel until the residual unbalance is no greater than 0.10 dyne-cm at 12,000 rpm. Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with delrin caps, Dwg. No. B-166037 to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope after each increment of balance. Visually inspect under 25x to 30x for contamination or physical change in bearings. Remove any trace of contamination. removing caps, clean the wheel thoroughly with suction hose.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 Place in a suitable closed glass container the cycling container, (2A3-10F177).

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.
Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.
Alt. Cycle: 32°F to 180°F

Equipment

Cycling Container; Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

19.1 Remove wheel from the dynamometer and place it in stand (A-88948.3). Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten with 11 to 13 oz. in. of torque. Care should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per(MC 25-304) may be used as an alternative material to tack screw heads.

19.2 With a microscope examine the area around the screw head and wipe off off any excess Loctite. (Loctite will not cure if exposed to air).
Repeat this procedure to all 8 screws.

19.3 To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures (A-88948.3),(A-92244)
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant type A
   American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per(SCD 2021552)

20 DYNAMIC BALANCING (Final)

20.1 Place the wheel in oven to preheat for 30 minutes minimum at 150°F. Remove the wheel from oven and place in dynamic balancer. With amplifier gain adjusted to 28 volts, check the final balance of the wheel and make necessary corrections to achieve maximum residual unbalance of 0.10 dyne-cm at 24,000 rpm.

NOTE: This check should be made with the wheel at operating temperature as follows:
The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.

2) Cover the stator housing and entire rotor platform with heater blanket chromalox 630-2, 115 volts, 25 watts, (R62) or equivalent.

3) Run the wheel at synchronous speed until the Alnor meter indicates 140°-145°F.

Equipment

Micro Dynamic Balancer, Model K-1
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

21.2 Clean off with vacuum hose and repeat 21.1.

21.3 Record final weight of wheel on(MC 25-811)(MC 25-628) and(MC 25-605).

21.4 Place the wheel in a covered glass container and store in moisture free atmosphere.

Equipment

Zeiss Stereo Microscope } or Equivalent
Vacuum hose

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure (MC 25-855)

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter (A-95721) firmly to the VS-10.

22.2 Thread lock-nut (A-92357) to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter (A-95721) very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut (A-92357) firmly against the bushing, using spanner wrench (A-92359).

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 25-50 mv. At this drive voltage the acceleration level of the float is less than 2 g's.
IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V.T.V.M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on(M.C. 811) within ± 0.25 microinch/lb.

22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on(MC -811) insert wrench (A-92262)in the + SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench (A-92262), and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on(MC 25-811) insert wrench (A-92262), and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in(M.C. 25-605)

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 3.0 microinch/lb. If the term ΔC is greater than 1.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4°/ min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in(MC -811). If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

22.14 Using a spade oiler, or other suitable tool, apply LCA-9, (SCD 2021529) (MC 25-302) to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14. Replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on(MC 25-605)

22.19 Refer to(MC 25-855)for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder (2A3-10A180-1.2) with the Fenwal Thermistor probe, into one of the IA balance ports.

23.2 Install the float into fixture (C-87364) and attach power and thermistor leads onto provided terminal strip.

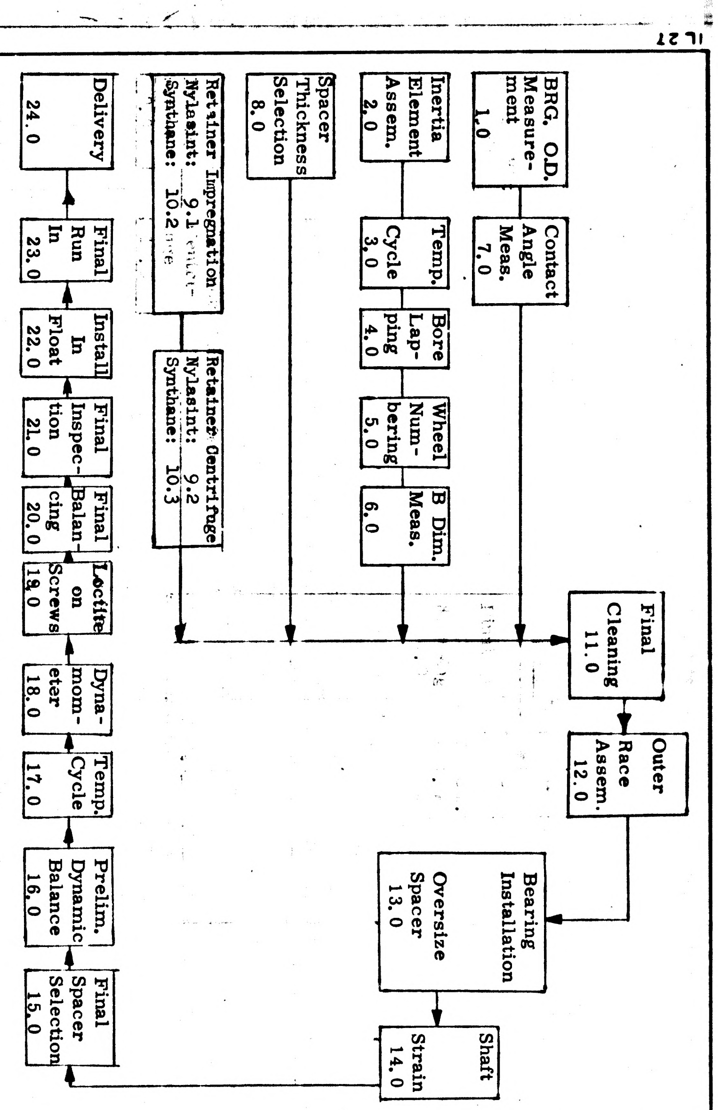
23.3 Install top plate (A-87364.1)on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 135°-140°F. With wheel at 135°-140°F turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per(MC 25-882)

24. DELIVERY

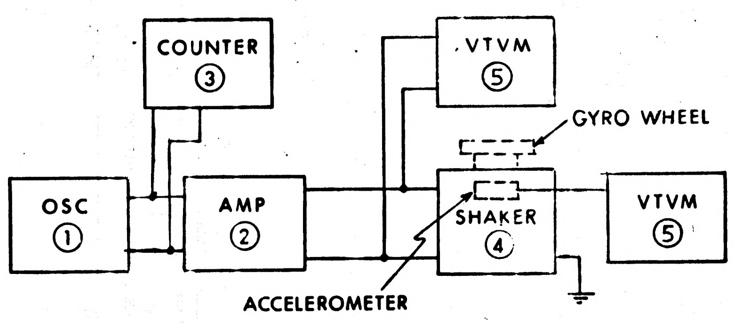
Continue float assembly per(MC 25-855)


BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation Nylasint: 9.1 Synthane: 10.2
Retainer Centrifuge Nylasint: 9.2 Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Loctite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

Fig. 1

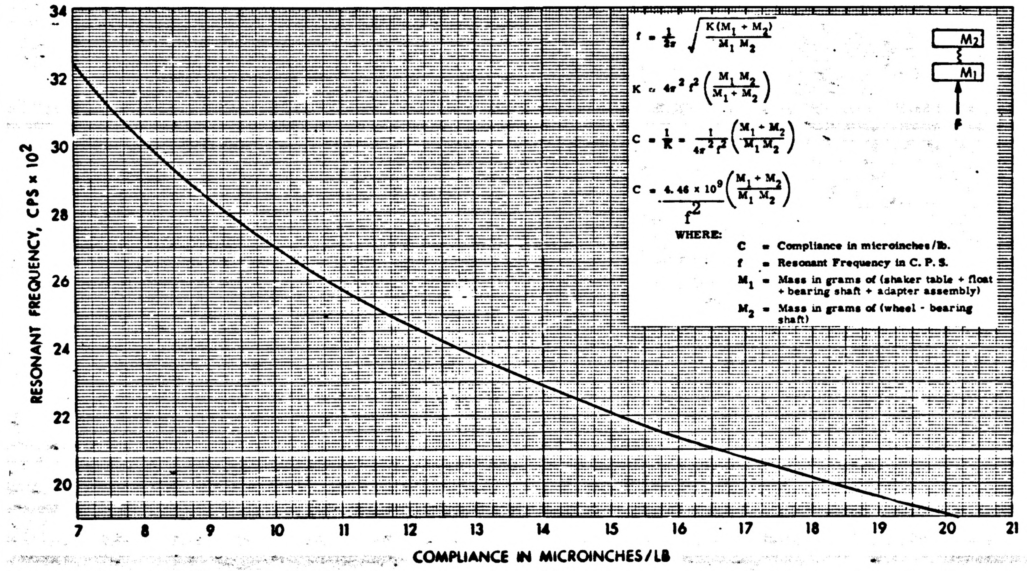
Compliance Checking Equipment
Apollo 2 Gyro


COUNTER ③
VTVM ⑤
GYRO WHEEL
OSC ①
AMP ②
SHAKER ④
VTVM ⑤
ACCELEROMETER

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. [illegible]

Fig 2

IL 27



$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.
f = Resonant Frequency in C. P. S.
M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)
M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

FIG 3

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INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY B. Rockower

DATE: September 8, 1967

MC 25-880

SHEET 24
OF 24

80

APOLLO II IRIG Specification
MC 25-881
Release Date ________
Release Revision —
Class A Release
TDRR 35599

Evaluation of Apollo II Wheel in Dynamometer

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		
8/1/68	A	36606	ALL	PRK	--
11/20/68	B	37035	Page 2	PRK	--

TP#11938

This MC specification consists of page i to____and 1 to 15 inclusive.

EVALUATION OF APOLLO II WHEEL IN DYNAMOMETER

1.0 General Requirements

The initial wheel evaluation will be made over a 200 hour qualification period using rundown time measurement, breakaway voltage measurement, minimum voltage to synchronous speed and torque monitoring as the critical parameters. During qualification,,wheel shall be operated in ambient of one half atmosphere of helium. Alternate: 5.0 psig helium. Prior to setting ambient, dynamometer fixtures shall be evacuated to 20 in. mercury vacuum and back filled with helium to one atmosphere. Repeat evacuation and backfull five times minimum.

1.1 Rundown Time Measurements

The wheel qualification rundown time measurements shall be taken twice in each 24 hour period with a minimum of four (4) hours between rundowns. After the first 50 hours of wheel qualification a minimum of one rundown time measurement may be taken in each 24 hour period except on weekends or holidays. The total number of rundown time measurements shall not be less than 12. To measure rundown time, switch off wheel momentarily to dissipate any overexcitation and proceed per MC 25-834. Wheel operating temperature, and other rundown data shall be recorded on MC-811.

1.2 Breakaway Voltage Measurements

The wheel qualification breakaway voltage measurements shall be made per MC 25-873 once every 24 hours during the qualification period. Record data on MC-811.

1.3 Minimum Voltage to Reach Synchronous Speed

The wheel must be capable of reaching synchronous speed at 26.6 volts. Minimum voltage measurements shall be made once every 24 hours during the qualification period. Record data on MC-811.

1.4 Torque Monitoring

The wheel qualification torque monitoring recording shall be performed during the entire 200 hour qualification period for acceptable wheels. Refer to MC 25-888 for the wheel qualification equipment specification. The recording shall be continous except for interruptions due to scheduled rundown time measurements and interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Disposition Points

There are two formal points in time for making wheel dispositions, namely the fiftieth and the two hundredth hours of wheel operations. Fig. 1 serves to clarify the use of these formal disposition points and indicates a wheel qualification program yield history. Dispositions at points other than the 50th and 200th hour are allowed but not required.

2.1 Fifty Hour Disposition

Within 24 hours after the completion of the first 50 hours of wheel qualification a disposition shall be made using the following criteria.

2.1.1 Rundown Time Repeatability

If the maximum difference between the four (4) rundown time measurements is greater than 10 seconds, two more measurements shall be taken at 15 min. minimum intervals to determine if rundown time is bad or if level is actually changing. Final disposition shall be made after 200 hours using all rundown time measurements (See para. 1.1).

2.1.2 Torque Monitoring Performance

The criteria for acceptance in the dynamometer evaluation lies in the interpretation of the recorded trace taken between each rundown time interval. In order to provide objectivity in this interpretation reference will be made to a number of characteristic forms of the dynamometer trace and specifications or limits imposed on each. The following identification pertains to dynamometer traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.
To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.1.2.1 Acceptable Torque Trace

The principal requirements for an acceptable wheel is performance during the monitoring period that is free of non-periodic or step torque variations greater than 75 dyne-cm. Fig. 2a,b,c represent acceptable torque traces with 2b and 2c indicating acceptable periodic variations. (The variations are due in this

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case, to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 150 dyne-cm. The maximum allowable variation in trace width during the total wheel monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period compared to the level exhibited during the period between the fifth hour of running and the first wheel rundown. The allowable increase is as indicated below.

5th Hour to 1st RDT Average Dyna. Torque	Allowable Maximum Trace Width at Any Time Average Dyna. Torque
25	75
50	100
75	100
100	125
125-150	150

2.1.2.2 Provisionally Acceptable Torque Trace

There are two categories of torque variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.1.2.2.1 Torque Level Disturbance

Fig. 3a is typical of torque trace exhibiting a disturbance of the torque level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than once during the 50 hour qualifying period as shown in Figure 1.

2.1.2.2.2 Test Equipment Influences

Fig. 3b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory torque trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller than this component of the torque trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

J. Publicover 53138-41-26
same size TP 5972

TDRR 14046 NOV 4 1964

J.PSYHOGEOS M.C.# 811 WHEEL DYNAMOMETER RUNNING DATA

WHEEL DESIGNATION	WHEEL NO.	FINAL WHEEL WT. gms.
BRG. MFG	TYPE OF BRG.	TYPE OF RETAINER

MIN. CURRENT TO START __________ MA/Ph

MIN. POWER TO START __________ WATTS/Ph

AXIAL COMPLIANCE MECHANICAL

COMPL. ________ μ in/lb

A_D = ________________ SECONDS

σ_D = ________________ SECONDS

DATE	START	STOP	TOTAL ELAPSED TIME HOURS	MINIMUM VOLTAGE TO START VOLTS/Ph	MINIMUM VOLTAGE TO SYNC. VOLTS/Ph	POWER AT SYNC. & 18 VOLTS WATTS/Ph	CURRENT AT SYNC. & 18 VOLTS IN MA	RUNUP TIME AT 18 VOLTS IN SECONDS	RUNDOWN TIME IN SECONDS 24000 TO 6000 / 6000 TO ZERO	SLOW RUNNING TORQUE IN Dy/cm	RUNNING TORQUE IN Dy/cm	TEMP °F	

TP5972 (REV B 12/4/62)

10x12 100%

the wheel accepted providing that it meets the other requirements of this specification.

2.1.2.3 Oil Jogs

Fig. 3c is a typical torque trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 720 dyne-cm-minute, the wheel shall be rejected.

NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area illustrated by Figure 5.

2.1.2.3.1 Modulation of Oil

If area of oil jogs are greater than 720 dyne-cm minutes then remove oil from retainer by following procedure: Use 2 dry retainers. The retainers shall be weighed immediately upon removal from 150°F oven. Record weight. Place retainers on shaft of wheel and slide up against bearing retainer and hold in positive contact. Bake in (150°-160°F) oven for one hour (period of time reference only). Remove one retainer at a time from wheel while still in oven and weigh quickly. Subtract first weight from second weight to determine amount of oil removed. The procedure may be repeated if oil jogs are still excessive.

2.1.2.4 Non Acceptable Torque Trace

Any torque trace resembling Figs. 4a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are squeal (Fig. 4b) intermittent squeal (Fig. 4a), low preload (Fig. 4b. c), incipient varnish failure (Fig. 4b, c, d, e, f) debris (Fig. 4b, d, e), loose wires (Fig. b, c), one ball group unstable (Fig. c, h) equipment malfunction Fig. 4i.

2.1.2.5 Retainer stability motion study

If a wheel is rejected because of non-acceptable torque trace, retainer motion shall be observed to assist in determining reason for wheel failure. Place wheel in milliwattmeter fixture (Dwg. E-159826). Wheel shall be

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operated in ambient one-half atmosphere helium of 5 psig and at operating temperature (137°F). Run wheel up to synchronous speed. Adjust binocular microscope (American Optical or equivalent) to 10 power and focus on one of the retainers of running wheel. With variable oscillator, externally trigger stroboscope with sufficient excitation to fire stroboscope and electronic counter. Set oscillator at retainer frequency (Ref. 243 Hz) and aim stroboscope at bearing as close as possible. Adjust oscillator until retainer appears to "stop" and observe stability of motion. Continue observation with retainer slowly drifting for possible signs of erratic behavior. Repeat observations with second bearing.

2.1.2.6 Other dynamometer requirements

The maximum variation in mean torque level shall not exceed 200 dyne-cm. The minimum allowable torque level shall be 800 dyne-cm (normal range 800-1800 dyne-cm, reference only)

2.2 Two Hundred Hour Disposition

After a minimum of 200 hours of wheel qualification a disposition shall be made using the following criteria.

2.2.1 Rundown Time

2.2.1.1 The RMS of all wheel rundown times (σ_D) shall be equal to or less than 3 seconds.

2.2.1.2 The RMS of the wheel rundown time (σ_D) shall be calculated using the following

$$\sigma_D = \sqrt{\frac{(T_1 - A_D)^2 + (T_2 - A_D)^2 + \ldots\ldots (T_n - A_D)^2}{n}}$$

A_D = Average run-down time to 6000 rpm

n = Number of run-down checks (no less than 12)

$T_1 \ldots T_n$ = Run down time to 6000 rpm

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the wheel assembly.

2.2.2 Breakaway Voltage Measurement Comparison

The breakaway voltage at the beginning and end of the wheel qualification period should be examined. Although no specification requirement is imposed herein, this information should be examined along with the rundown times and torque traces. Like decreasing rundown times, a significant increase of breakaway voltage is indicative of incipient bearing failure.

2.2.3 Torque Monitoring Performance

The criteria of section 2.1.2 are to be applied to the 200 hour disposition.

2.2.4 Synchronous Voltage Measurement Comparison

Minimum voltage to reach synchronous speed at the beginning and end of the wheel qualification period should be compared. This information should be examined along with breakaway voltage measurements, rundown times and torque traces for any indication of incipient bearing failure.

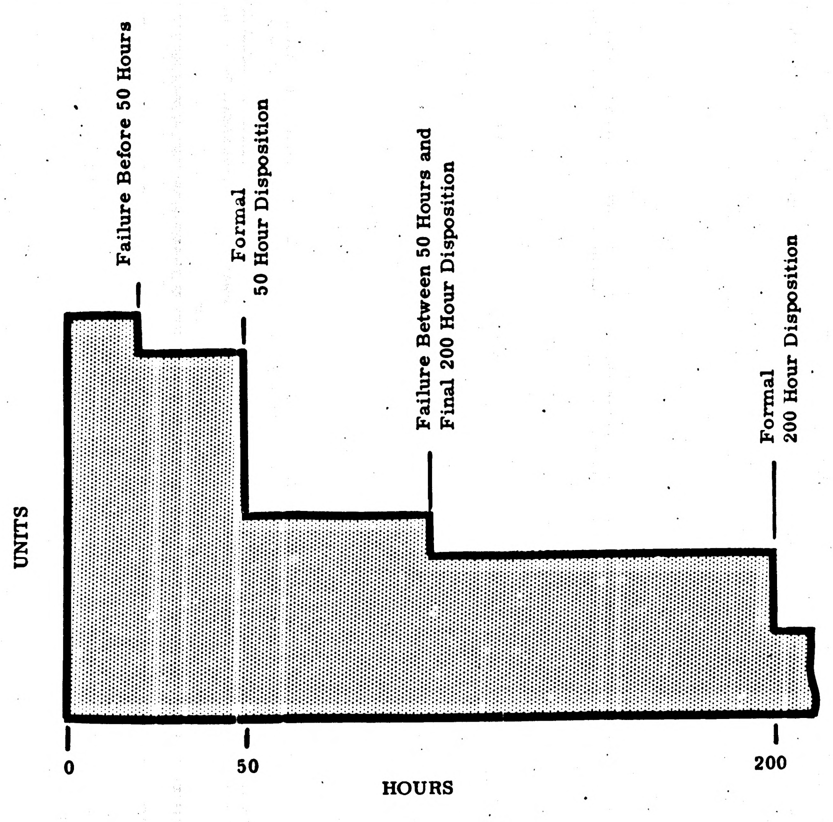


Fig. 1 Illustrative Wheel Qualification Program Yield History.

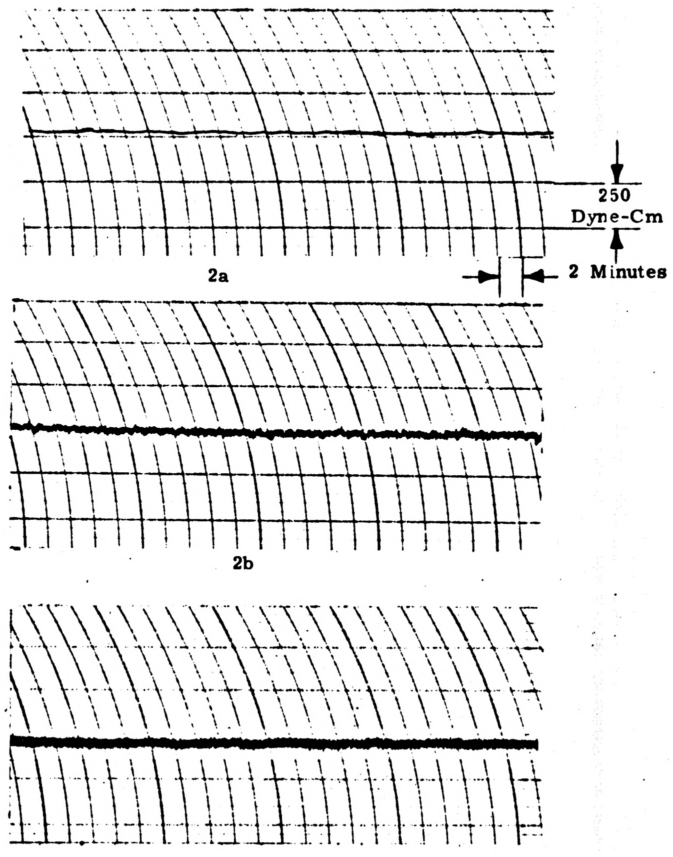


Chart Speed	6 inches/Hour
Recorder Calibration	25 D.C./mm
Recorder Time Constant	0.3 sec ± 15%

*

Fig. 2 Acceptable Torque Traces

* Chart information applicable to figures 2, 3, 4,

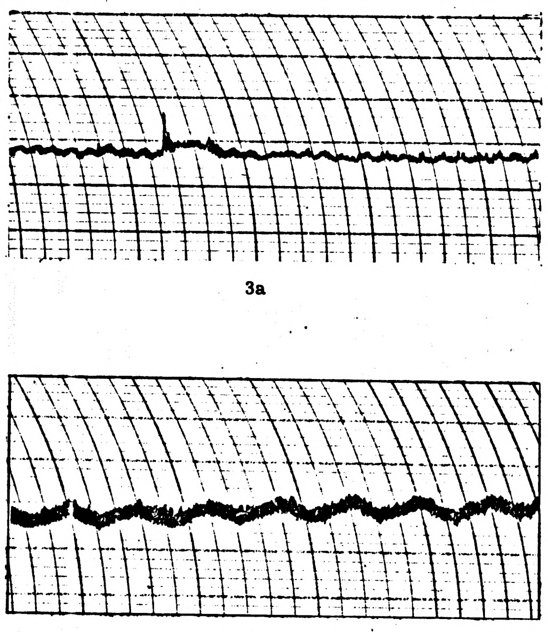
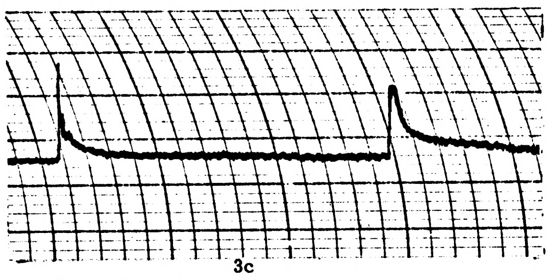


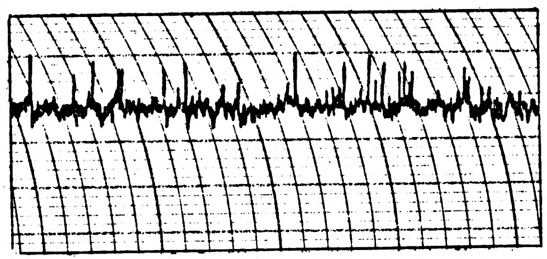
Fig. 3 Provisionally Acceptable Torque Traces



3c

Probable Cause

Oil jog	Instantaneous torque increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

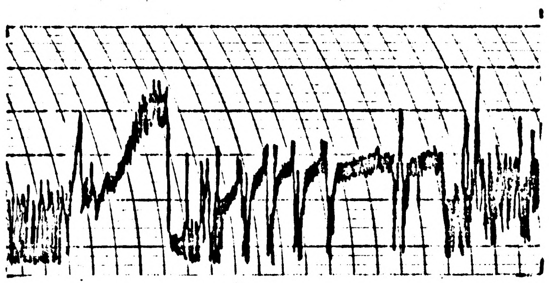


4a

Probable Cause

Excessive Oil Intermittent Squeal	Instantaneous torque increase caused by the retainer superimposed on a rough and irregular power trace.

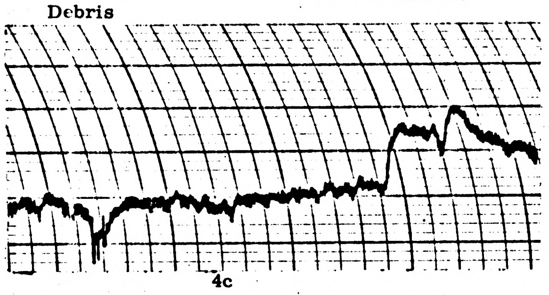
Fig. 4 Non-Acceptable Torque Traces.



4b

Probable Cause

Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular torque trace that could be attributed to any or all of the listed causes singly or in combination.

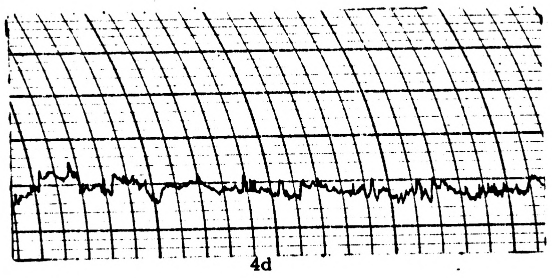


4c

Probable Cause

Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 4b

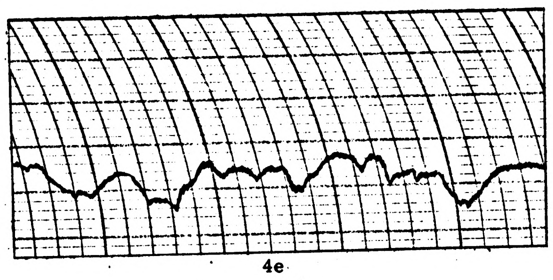
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4d

Probable Cause

Varnish Debris	This is typical of a varnish or debris induced torque variation.

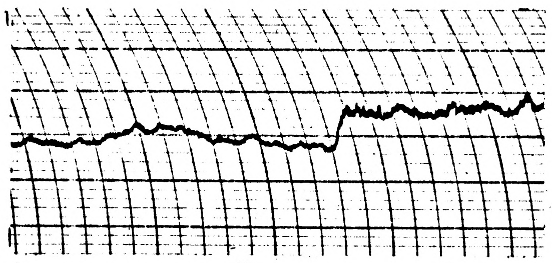


4e

Probable Cause

Varnish Debris	A torque variation induced by debris or varnish, not as common as 4e but a positive indicator of an incipient failure.

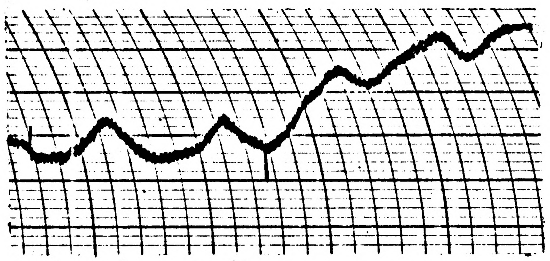
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4f

Probable Cause

Slight Varnish	Early indication of a varnish build up on one or both bearings.

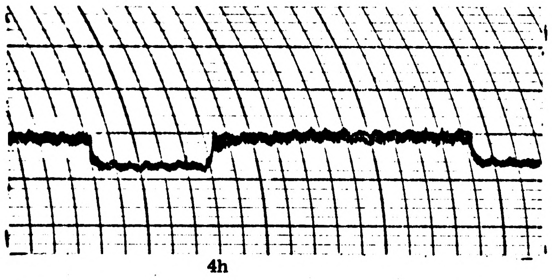


4g

Probable Cause

Varnish	This trace shows a steady increase in torque with a superimposed sinusoid attributable to a temperature control cycle.

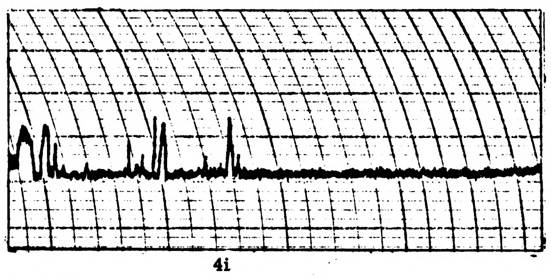
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4h

Probable Cause

One Ball Group Changing Angular Velocity	Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



4i

Probable Cause

Equipment	The torque variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

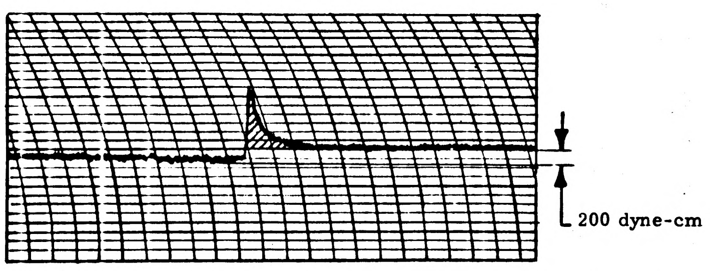


Fig. 5

Calculate cross hatched area of oil jog as called out in paragraph 2.1.2.3

APOLLO II IRIG Specification
MC 25-852
Release Date Jan. 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
5/7/65	B	18998	1, 3	WAR.	WJR

TP#11938

This MC specification consists of page i to ___ and 1 to 5 inclusive.

Rev. A 11/20/64 Revised and Rewritten

Rev B 5/7/65

ASSEMBLY OF SHROUD TO GYRO UNIT, APOLLO II

SHROUD END COVER ASSEMBLY

Equipment Required

450 Watt Hot Plate
60 Watt Soldering iron Pyramid Tip
Variac
Solder - 96.5 Tin; 3.5 Silver
Solder - 60 Tin; 40 Lead
Flux Kester 891 - Kester 1571
Artist Brush #3 - Acid Brushes

1. End Cover Preparation
   - A. Clean the end cover ultrasonically in trichlorethylene, followed by freon rinse.
   - B. Leak check end cover for porosity using fixture 2A-10B182.0.
2. Tinning Procedure
   - A. Place the end cover on hot plate and heat to 250°F. ± 10°.
   - B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.
   - C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.
   - D. Repeat steps B and C on inside of cover.
   - E. Remove from hot plate and allow to cool.
   - F. Tin the 2.443 diameter of the end cover using 60-40 solder and Kester 891 flux.
3. Cleaning Procedure
   - A. With an acid brush scrub the end cover using trichloroethylene or some other suitable solvent.
   - B. Follow by scrubbing under running hot water using Ajax, powdered Boraxo or equivalent.
   - C. Thoroughly rinse under running hot water and dry.

---

4. Assembly of Seals to End Covers
   - A A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux.
   - B. Refer to step #3 for cleaning.
   - C. Place end cover on hot plate and heat to 490°F x ± 10°F.
   - D. Apply 1571 flux to tinned area.
   - A E. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position.
   - F. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.
   - G. Carefully remove from the hot plate and allow to cool.
   - H. Repeat cleaning procedure #3.
   - I. Polish the end covers using 305A lapping compound, followed by 38+1200 compound. Final clean as in step #3.
   - J. Seal the degassing plug hole with the aluminum ball and seal screw. Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.
   - K. Hi Pot - 250 volts (DC).
5. Main Cover Preparation
   - A. Degrease in trichloroethylene, followed by freon rinse.
   - B. Tin the 2.440 diameter and two .010 deep relief with 60-40 Solder and Kester 891 flux.
   - C. Refer to step #3 for cleaning.
6. Insert Preparation
   - A. Degrease in trichloroethylene, followed by freon rinse.
   - B. Tin concave side with 60-40 solder and 891 Kester flux.
   - C. Refer to step #3 for cleaning.
7. Internal Connector Assembly
   - A. Check the connector assembly for shorts or opens.

   - B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.
   - C. Carefully clean all joints with trichlorethylene and artist brush, followed by a freon rinse.
   - D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.
   - B E. Leak check assembly as in J of step #4.
   - F. Apply LCA-9 adhesive (MC 25-302) over the glass seals and any exposed wires.
   - G. Form the wires carefully at terminal to provide a 180° bend strain relief.
   - H. With lacing cord make two ties in each pair of six leads about one inch apart.
   - I. Make a final electrical check on assembly.
   - J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)
8. Assembly of Shroud Parts to Gyro Unit
   - A. Stablize fixture C-130409 at 140°F. $^{+0°}_{-5°}$ prior to removing unit from storage oven.
   - B. Select the adapter A-130410 which will center the main cover on the gyro unit.
   - C. Place the adapter on the gyro and mount in the thermally stabilized well with the signal generator end up.
   - D. The fit of the main cover to the unit should be line on line to .0004 loose.
   - E. Carefully inspect the OD of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

APOLLO II IRIG Specification
MC 25-862
Release Date 25 Nov. 1964
Release Revision A
Class A **Release**
TDRR 14531

ASSEMBLY PROCEDURE FOR SUSPENSION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	NASA
3/18/65	B	17644	1, 2, 3	WK.	WJR

TP#11938

This MC specification consists of page i to ___ and 1 to 3 inclusive.

APOLLO II IRIG Specification
MC 25 -882
Release Date ________
Release Revision —
Class A Release
TDRR 35599

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	RT[illegible]	[illegible]
6/21/68	A	36392	3, 11	[illegible]	See TDRR
8/1/68	B	36605	2	[illegible]	See TDRR

This MC specification consists of page 1 to ___ and 1 to 11 inclusive.

TP#11938

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm

n = Number of run-down time checks (no less than 8)

$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic or step power variations that are greater than 20 milliwatts. The maximum variation in mean power level shall not exceed 50 mw. Figs. 1a, b, c represent acceptable power traces 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.

The maximum allowable trace width during the monitoring period for an acceptable wheel is 40 mw. The maximum allowable variation in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11-15	20
15-20	25
20-25	30
25-30	35
30-35	40
35-40	40
[illegible]	[illegible]
[illegible]-25	[illegible]

2.2.2 Provisionally Acceptable Power Trace

There are two categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 Test Equipment Influences

Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.2 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-1 are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig. 3l).

PREPARED BY: Robert A. Booth
DATE: February 24, 1964
MC 25-852

F. Align the open ports in the main cover with the + SRA and + IA gyro axis and slide the main cover all the way down until it seats on the adapter A-130410.

G. Install the end cover assembly on the unit carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

H. Perform an electrical check for correct resistances, opens and grounds.

I. Apply a minimum amount of 1571 Kester flux to main cover - end cover joint with a piece of solder.

J. Use a 60 Watt iron and 60-40 solder to make the joint while the guide post is slowly rotated by hand.

K. Place the well in a horizontal position on fixture and re-flux joint with 1571 Kester flux. Complete soldering joint making sure that the gap is completely filled.

L. Excess solder can be cleaned off using a sharp edge dental tool and a hard rubber abrasive eraser.

M. Raise the guide post and invert the instrument in the fixture at the same time removing the adapter A-130410.

N. Install the second cover assembly as before.

O. Unit is ready for preliminary testing.

A 9. Final Shroud Seal

A. Apply minimum amount of 1571 Kester flux to the two .010 deep reliefs on the main cover and concave surface of the inserts.

B. Position insert on main cover so as to follow general contour of 2.460 dia.

C. Using a soldering iron and 60-40 solder make the insert - main cover joint and remove excess solder.

NOTE: A vee block or similar fixture maintained at $140^{+0^\circ}_{-6^\circ}$ F. may be used.

PREPARED BY:
DATE:

A 10. Leak Check of Shrouded Unit

Stabilize leak check fixture C-127683 at $140^{+0^\circ}_{-5^\circ}$ prior to positioning unit.

With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S. S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683.

Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the terminals, ports and main seam at the end with helium or argon. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

Before inverting the unit to leak check the other end, the first degassing seal will have to be opened up again. The deformed ball seal can be removed with a small screwdriver.

Final Seal as a Hermetic Assembly

While still on the leak check fixture and with 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug.

Store in a $140^\circ\,^{+0^\circ}_{-5^\circ}$ oven awaiting final testing prior to delivery.

11. Continue with prealignment per MC 25-847.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC25-862

SHEET 1
OF 3

Rev A 10-30-64
RevB 3-18-65

ASSEMBLY PROCEDURE FOR SUSPENSION, APOLLO II IRIG

1.0 Core Winding Preparation

1.1 Assemble winding arbor B-82382 (2 parts) with suspension core A-2021686. Be sure to assemble winding fixture so that winding arbor extension can be used if needed. A

2.0 Suspension Core Winding

2.1 Suspension can be hand wound or machine wound.

2.2 Winding direction, number of turns per pole, type, and size wire are given on 2021657. A

2.3 Coil pair ends shall come out on Small Dia. side of suspension core.

2,4 Strip coil lead ends approximately 1/2" from end.

2.5 With an ohmmeter check each coil pair for grounding to core upon completion of winding. Identify Pole #1.

2.6 Determine pole-pair ends by continuity method and twist individual coil pair ends together to keep separated.

2,7 Measure coil-pair resistances with a Wheatstone Bridge. The four Resistance readings shall have a spread of 5% max.

3.0 Forming

3.1 Insert slot papers 2021584 in each slot. Use nonmetallic instrument for forming. A

3.2 Trim slot papers to approximate length as shown.

3.3 Form coils by sliding forming fixtures over winding arbor until forming fixture ends are flush with winding arbor ends.

3.4 Most units do not require forming but it is a good idea to run through the steps anyway.

4.0 Lead out Wire Assembly

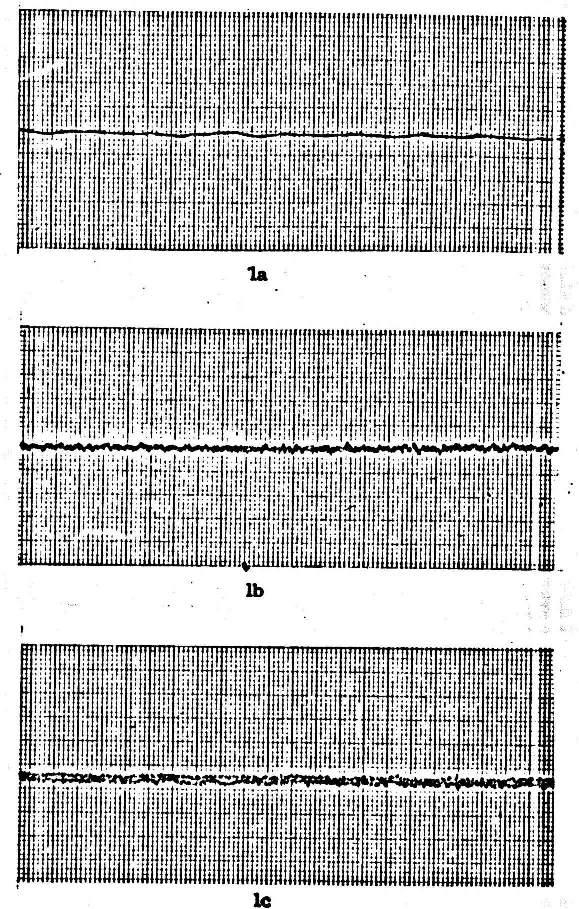
4.1 Slots where lead out wires are to be inserted require 2 slot papers. Follow same procedure as previously outlined.

4.2 Make lead out wire clearance hole between slot papers with a non-metallic instrument.

4.3 Strip lead out wires 1/8" back from end and tin (60-40 Solder Kester 1571 Flux). Push lead out wires up between slot papers until 1/2" is protruding above coil.

4.4 Strip and solder (60-40 Solder Kester Flux) coil end wires to appropriate lead out wires. Trim excess lead out wire for smooth joint.

TDRR 14531 NOV 25 1964


1a

1b

1c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1. 3 sce ± 15%

Fig. 1 Acceptable Power Traces

Fig. 2a Deleted

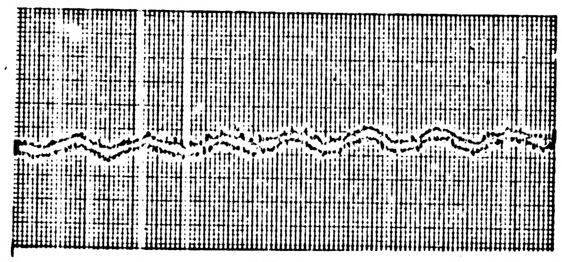
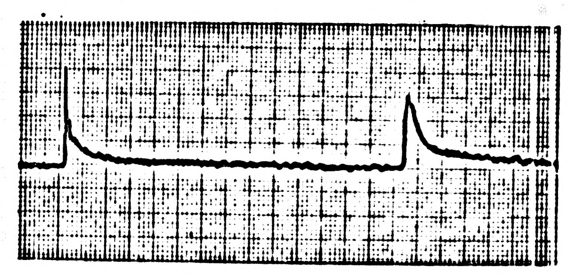

2b

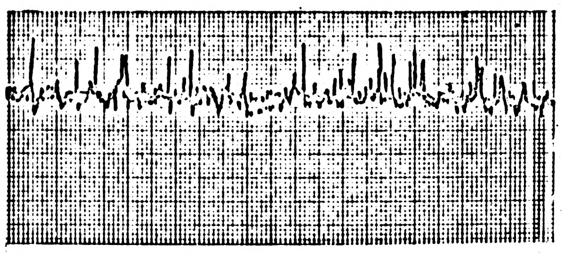
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

Fig. 2c Provisionally accepted power trace due to oil jog.

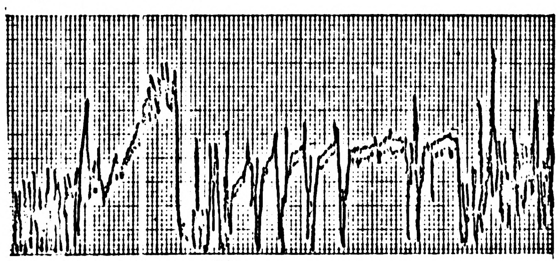

3a

Probable Cause

Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer superimposed on a rough and irregular power trace.

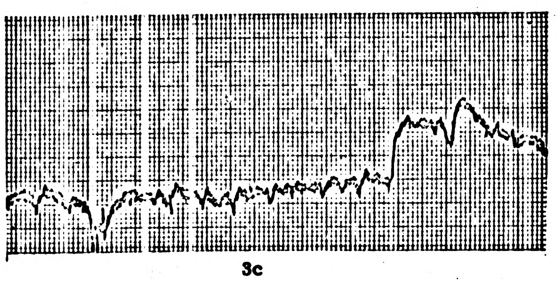
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

Probable Cause

Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.


3c

Probable Cause

Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces

PREPARED BY: D. Freeman, D. Zickefoose SHEET 2
DATE: February 25, 1964 MC 25-862 OF 3

4.5 Pull lead out wires back so that solder connection is below surface of coils.

4.6 Remove Winding Arbor.

4.7 Wash unit ultrasonicially in synthetic Methanol for approximately 1 minute to remove flux residue then wash ultrasonically in freon for approximately 10 minutes.

5.0 Preliminary electrical tests

A 5.1 Make polarity check per 2021657. Make insulation tests with 250V megohmmeter DC(500 megohns minimum).

6.0 Final Lead Out Wire Assembly

B 6.1 Apply LCA-9 to top and bottom of cell slot to secure the lead out wire.

BA 6.2 Apply thin coating of LCA-9 on common coil lead that runs across top of other coils.

6.3 Cure Assembly for 2 1/2 hours at 180°F.

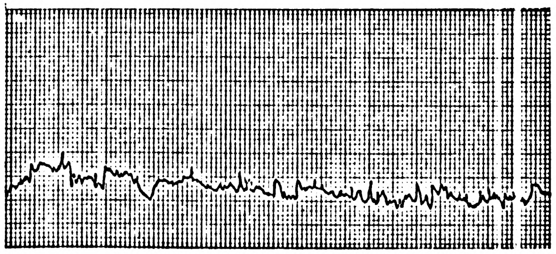
7.0 Prepot Electrical Tests

7.1 Perform Shorted turn test.

7.1.1. Connect and excite per Fig 1.

7.1.2 Series tune each of four coil pairs, recording V in and C at resonance.

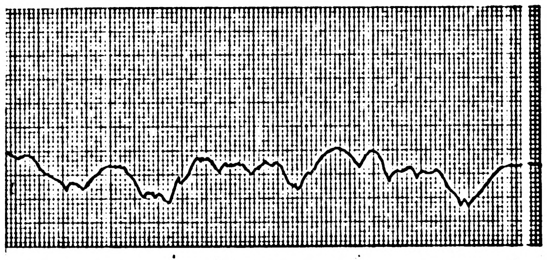
7.1.3 The 4 V in readings shall be within 5% of one another and the capacitors spread shall be 5% maximum.


3d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced power variation.


3e

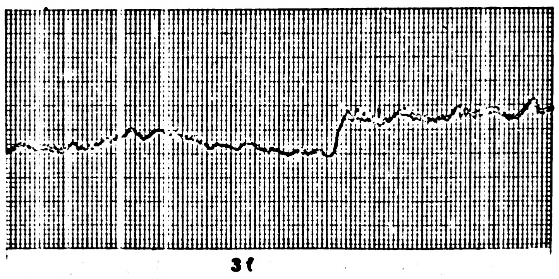
Probable Cause

Varnish
Debris

A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

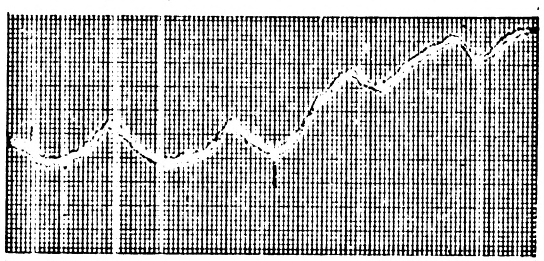
Fig. 3 (Cont.) Non-Acceptable Power Traces.


3f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.


3g

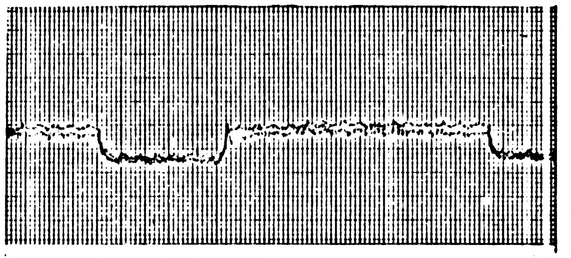
Probable Cause

Varnish

This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

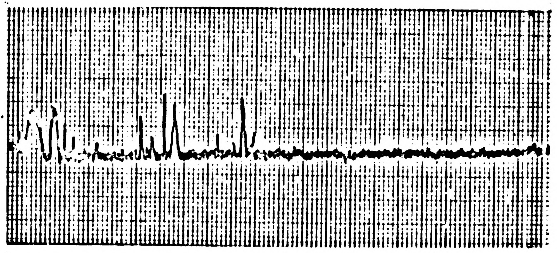
Fig. 3 (Cont.) Non-Acceptable Power Traces.


3h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.


3i

Probable Cause

Squeal

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

TDRR 36392 JUN 21 1968

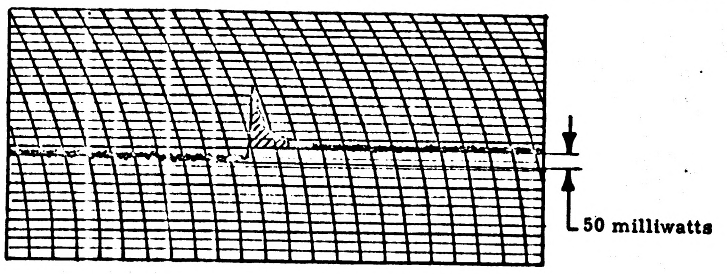


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.3.

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman, D. Zickefoose
DATE: February 25, 1964 MC 25-862

SHEET 3
OF 3

B 7.2 Check magnetic characteristics per MC 25-[illegible]2.

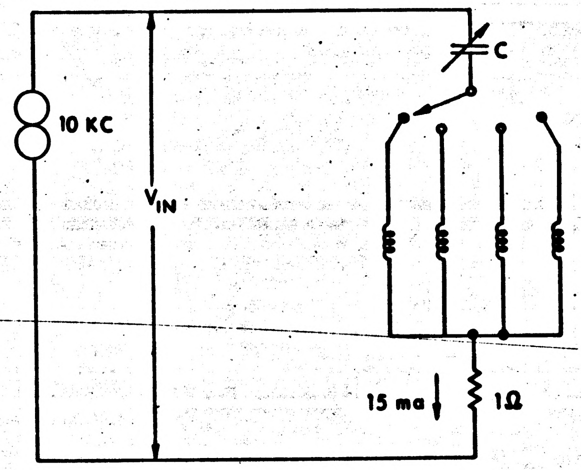


FIG. 1

APOLLO II IRIG Specification
MC 25-834
Release Date Nov. 4, 1964
Release Revision A
Class A Release
TDRR 14046

25 IRIG Run Down Time Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2-6-68	B	35602	1		

This MC specification consists of page 1 to____and 1 to 1 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: R. Sheaff
J. Psyhogeos
DATE: July 3, 1962

MC # 25-834

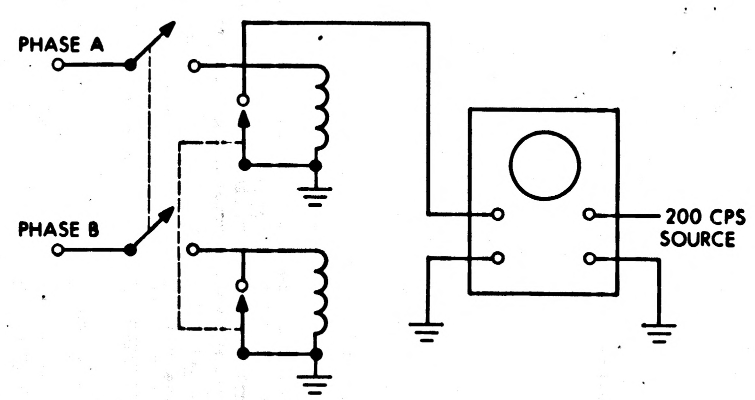
SHEET 1
OF 1

A

25 IRIG RUN DOWN TIME PROCEDURE

With the wheel in sync at 28 V wheel excitation, open the line between the wheel power supply and the wheel windings. Immediately after opening (.2 to .5 seconds), place short circuit across Phase A and Phase B of the wheel for 5 seconds duration. Measure and record RDT from 24,000 to 6000 RPM and from 6,000 to 0 RPM.

Take one measurement only.



Rev. A 9/10/64

IL 27

APOLLO II IRIG Specification
MC 25-884
Release Date ______
Release Revision —
Class A Release
TDRR 35599

NYLASINT RETAINER PROCESSING SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	RSmith	
3-22-68	A	35932	1, 2, 3		--
8/1/68	B	36622	1-3		--

TP#11938

This MC specification consists of page 1 to ___ and 1 to 4 inclusive.

TDRR 35932 MAR 22 1968

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (Material per Dwg C-2021819) with V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg C-2021816. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in. hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 20X magnification. Repeat steps a, b, or c, if necessary.

---

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150° -160°F and 29 1/2 in. hg. minimum.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0 ± .5 grams/minute at a line pressure of 80 psi minimum. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time(Tolerance: ±5 sec)
Ball Pockets	2 min. each pocket
Outer Diameter	2 min. total
Edges	2 min. each edge
Inner Diameter	20 sec. total

NOTE: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period)

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° ± 150°F and 25-50 microns.

f. Equipment
S. S. White Industrial Abrasive unit
model G
201 East 42nd Street
New York, N. Y. 10017 or equivalent
NOTE: Handpiece 351-1793y (approx .040 dia) without nozzle attachment shall be used as a nozzle

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

---

c. Finally inspect retainer for absence of burrs, contamination, and damage under 20X magnification.

d. Holes from pull out of solid nylon inclusions will be permitted on the I.D. surfaces and side edges of the retainer. Pull out at the edges of the ball pocket surfaces which intersect the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. and O.D. surface and the ball pocket surface. The depth of blend may not exceed .003 inches into the ball pocket or the O.D. or I.D. surface. (See fig. 1).

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material. No inclusions will be permitted where ball makes contact in pocket. NOTE: Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown and black) inclusions are acceptable only if they are imbedded below the surface of the retainer surface.

8. Oil Absorption Test

a. Check retainers for oil absorption test per MC 25-911.

b. After oil absorption test reclean the retainers per paragraphs 6c, 6d, and 6e of this specification.

9. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage enviroment.

c. The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.

MC 25 [illegible]

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884
SHEET 4
OF 4

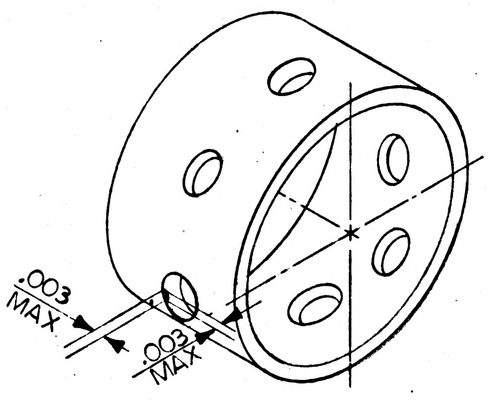
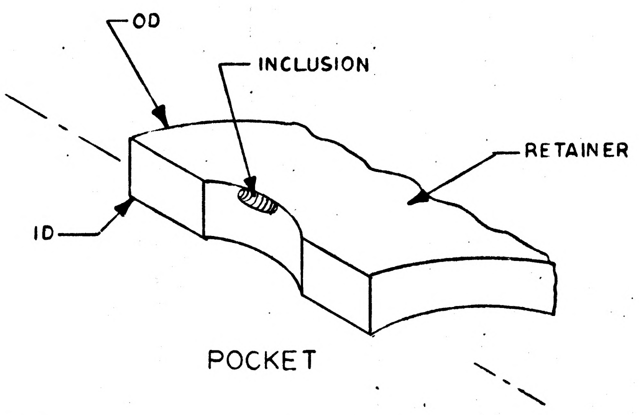

.003
MAX
.003
MAX

FIG 1
BALL POCKET BLEND


OD
INCLUSION
RETAINER
ID

POCKET

APOLLO II IRIG Specification
MC 25-865 B
Release Date 4 Nov, 1964
Release Revision -
Class A Release
TDRR 14046

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/19/65	A	18996	1, 3, 4	WAR	WJR
11/2/66	B	32079	2	THGW	

TP#11938

This MC specification consists of page ~~to~~ and 1 to 4 inclusive.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
TDRR 14046 NOV 4 1964
PREPARED BY: James Psyhogeos
DATE: September 1, 1964
MC 25-865
SHEET 1 OF 4

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

A 1. ENVIRONMENTAL CONDITIONS 45% Humidity $75^{\circ}F \pm 2^{\circ}F$

2. CRITICAL AREAS--The critical areas shall be as shown in Figure 1.

3. ACCEPTANCE CRITERIA -- The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination of 30 power magnification.
The critical areas of the races shall show a characteristic ground and polished, honed or lapped finish.
The critical areas shall be free from tool marks, chatter waves, grinding scratches, rust, seams, inclusion, and pits, except as modified by the following:
   - a) A pit shall be any imperfection of a size such that the dimension across its major axis is greater than 0.0005 inch. Any imperfections less than this are acceptable.
   - b) No pit shall exceed 0.0012 inch across its major axis and no two pits shall be closer than 0.012 inch.
   - A c) The maximum number of pits in the critical areas shall not exceed four per part.
   - d) Scratches, comet tails, grind tears and cuts running circumferentially in the critical ball track area shall not exceed 0.0012 inch in width, and no raised metal is acceptable.

Rev. A 12/14/64

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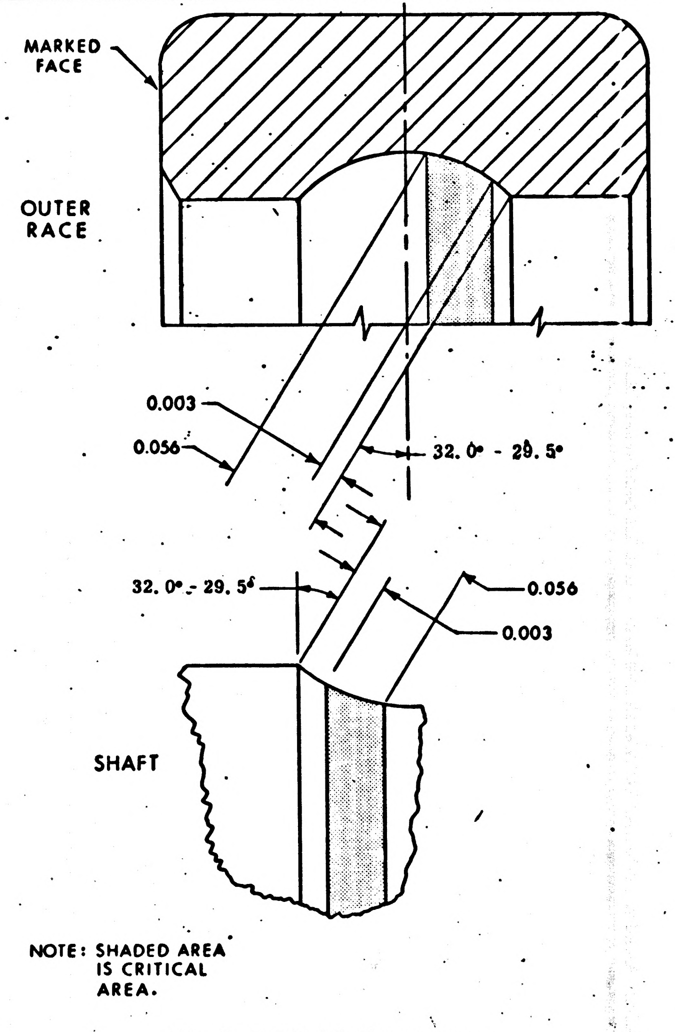
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
TDRR 32079 NOV 2 1966
[illegible] [illegible]
PREPARED BY: James Psyhogeos
DATE: October 1, 1964
MC-25-865B
SHEET 2 OF 4



NOTE: SHADED AREA IS CRITICAL AREA.

Fig. 1 Critical ball race areas.

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PREPARED BY: James Psyhogeos
DATE: October 1, 1964
MC 25-865
SHEET 3 OF 4

   - e) Scratches across the critical area shall not exceed 0.0005 inch in width.
   - f) No rust shall be present.

4. BALLS
   - a) The ball luster shall be very bright and the surface matte must be very fine. The following criteria shall determine the acceptability of the balls after microscopic examination under 10 power magnification.
     - (1) Defects---There shall be no noticeable defects as follows:
       - (a) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets in excess of 0.0012 inch width.
       - (b) Stains and rust - none
       - (c) Burrs - none
       - (d) Scratches - 0.0005 inch wide, showing no raised metal
       - (e) Flats - 0.002 inch maximum width.

5. Non critical Areas. - Non critical areas shall be all those areas not covered by the requirements of Paragraphs 2 and 3.
   - a) Acceptance Criteria. - The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination under 10 power magnification.

Defect	Ground Surfaces	Chamfers, Undercuts, Threads and Machined Bores
(1) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets.	0.003 inch	None which affect dimensional tolerances.

Rev. A 12/14/64

APOLLO II IRIG Specification
MC 25-855
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4-30-65	B	18829	1, 4, 5	WK	WJR

This MC specification consists of page 1 ~~15~~ and 1 to 7 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 1 OF 7

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.

1A. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA________ -SRA________

Record I. D of hemisphere shaft bore

+SRA________ -SRA________

Average Interference

+SRA________ -SRA________

2. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

A 3. Clean all the float parts in trichloroethylene followed by a freon rinse.

4. Weigh all the float parts and record information on sheet #6.

5. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Clean the parts as in step #3.

Rev A 10-26-64
Rev B 4-30-65

6. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

7. Measure and record the following:

A) O. D. of stator________

B) I. D. of gimbal________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".

C) Average interference________ (.0001-.0003)

TDRR 14531 NOV 25 1964

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CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 2 OF 7

8. Install the motor stator into the gimbal as follows:
   - A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.
   - B. Place the bushing A-92287 into the pressure plate.
   - C. Assemble the motor stator to the pressure plate A-87423.
   - D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.
   - E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O. D.
   - F. Remove the gimbal and fixture base from the hot plate.
   - G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.
   - A H. Remove fixture and check centering of the stator in the gimbal. Check continuity.
   - A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

9. Weigh gimbal and record________ gms.

A 10. Grind I. D. of motor stator as per drawing 2021625.

11. After grinding, perform visual inspection, and clean this assembly in varsol followed by a freon rinse. Check continuity.

12. Weigh gimbal and record________ gms.

A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

13. Power Lead Installation
   - A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F oven for 1/2 hour.
   - B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F.

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CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 3 OF 7

   - C. Repeat step "B" on oppostie end of gimbal.
   - D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F.
   - E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F.

14. Install .062 diamter ball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10 x 10^{-8} ATM cc/sec. Leak rate ________

A 15. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt. cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10 x 10^{-8} ATM cc/sec.

Leak rate ________

16. Remove the sealing screw and .062 diameter ball from the degassing hole.

17. Assembly of wheel to float
   - A. Thoroughly clean all float parts in filtered freon.
   - B. Mount the +SRA float hemisphere on fixture B-88921 and place on thermostatically controlled hot plate set to 350°F + 15°F and allow to heat for five or ten minutes.
   - C. Carefully remove the wheel from sealed plastic bag. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide in-to the hemisphere until it bottoms.

A NOTE: Nylon gloves or finger cots to be worn when handling wheel.

18. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

19. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

20. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.

21. Heat the -SRA hemisphere as in "B" of step #17.

22. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: James Psyhogeos
DATE: October 1, 1964

MC 25-865

SHEET 4
OF 4

(2)	Stains, rust	None	No rust, stains acceptable.
(3)	Burrs,	None	None which affect dimensional tolerances.
(4)	Scratches	None which affect dimensional tolerances	None which affect dimensional tolerances
(5)	Flats	None which affect dimensional tolerances	None which affect dimensional tolerances

6. Retainer - Visual Appearance.- The retainers must meet the minimum standards of freedom from burrs, fuzz, chips, or cracks as established by visual gauge GA-600260, details 3 and 4, or equivalent when examined under 20X magnification.

7. Contact angle determination - All necessary components of the contact angle shall be measured in accordance with the following formula to determine the contact angle:

$$\text{Cosine } \beta_o = \frac{E}{d}\left[1 - \left(\frac{2\,N_E}{N_i}\right)\right]$$

where E = pitch diameter of 0.249450 (print nominal value)
d = average ball diameter of row (vendor supplied information)
N_E = number of revolutions of the retainer
N_i = Number of revolutions of the inner race
β_o = contact angle

Rev. A 12/14/64

23. Carefully assemble the wheel and +SRA hemisphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

24. Balancing the float in Air

A   A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

25. The float at this time is complete except for the rotors and balance weights. Weigh the float and record ______________ gms.

26. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T.I.R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 2.

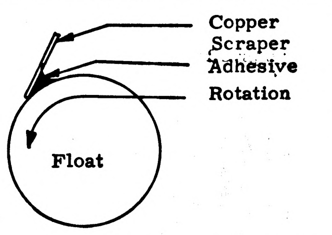
B   28. Refer to MC 25-803 or MC 25-869 for instructions on setting the +SRA bushing.

27. Solder (4) 18" long lengths of #30 wire to the power leads using 60-40 Kester solder and 1571 flux.

B   29/ Cement the float joints as follows fixture. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 180°F oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 180°F max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours t 180°F.

Rev. B 4-30-65 (Revised & Retyped)

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms.

B. Place a 2-56 x 3/32 long S.S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

The following alternate procedure may be used:

> Install float in fixture as described above. Draw a vacuum of 15" Hg and then admit helium to 0" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as above.

C. Weigh the float and record ______________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. ______________ gms.

31. Leak check and record ______________ atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A   32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min.

33. Leak check and record ______________

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A   34. Refer to MC 25-803 or MC 25-869 for float run-in requirements.

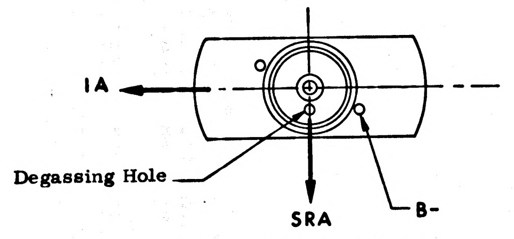
FLOAT WEIGHT RECORD

Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
A-87287	4	Power Lead-in		.092	
A-107251	8	Balance Weight (Final Rot. Adj.)		.740	
A-107252	4	Balance Weight Spring		.018	
B-87391	2	Centering Shim		.013	
B-87374	2	Bushing	1	1.676	
Comm'l.	1	#2-56 Sealing Screw		.037	
Comm'l.	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
C-87373	2	Hemisphere		14.701	
D-112977	1	Gimbal		26.051	
B-87289	1	Motor Stator (Finish Ground)		18.800	
C-118575	2	Rotor Assy. *		32.968	
C-87341	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	18.702		
	As Req.	Adhesive for Sealing		.100	
A-84046	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

A

*Rotors installed at final assembly.



(View from T.G. End)

Fig. 1

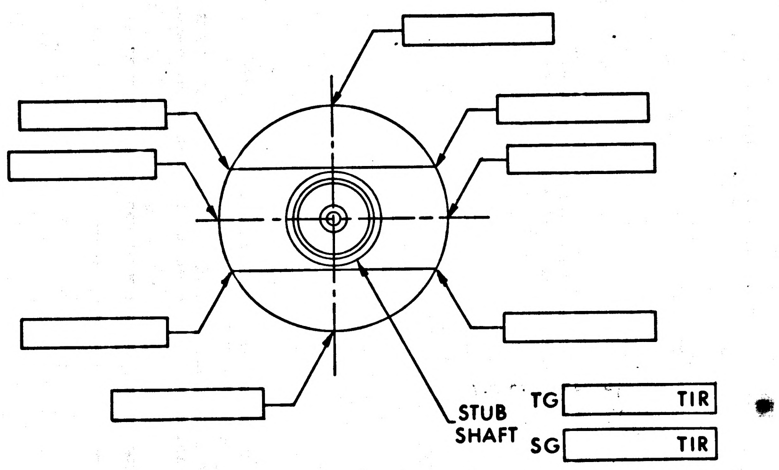


Fig. 2 Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC 25-856 B
Release Date Nov. 25 1964
Release Revision A
Class 1 Release
TDRR 14531

TITLE: Main Housing Assembly Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
3/19/68	B	36403	1	PRK	

TP#11938

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

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INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
PREPARED BY: C. J. Cormier
DATE: 19 March, 1968
TDRR 35403
MAR 19 1968
MC 25-856 B
SHEET 1 OF 2

MAIN HOUSING ASSEMBLY PROCEDURE

1.0 Lap the two (2) clamping caps, and the four (4)#00-96 screws, also the 0.218" diameter of the two main housing ports with fixture, 2A3-10B153, using 305A lapping compound. Refer to MC 400 for handling of beryllium.

2.0 Clean all the parts ultrasonically in trichloroethylene for five minutes minimum, followed by an ultrasonic rinse in clean freon for the same time period.

3.0 Lapping the End Housing to the Main Housing

A. Assemble the end housing to fixtures 2A3-10B153. Lap the mating taper of the end housing to the main housing using #305A lapping compound until there is a gap of 0.0005" to 0.001" between the end housing shoulder and the main housing face.

B. Clean the end housings and main housing by scrubbing while immersed in warm varsol 90°F ± 5°, followed by a thorough rinsing in clean freon.

C. Lightly blue the end housings and check its fit to the main housing. There should be 70% circumferential contact minimum.

D. Clean off the bluing with a Kimwipe dampened in acetone, followed by cleaning as in step "B". Scribe the ends of the main housing and the mating end housing with # 1 and # 2 for later identification.

4.0 Measure and record the dimensions indicated on next page.

5.0 Store the main housing and selected parts in a clean container until required.

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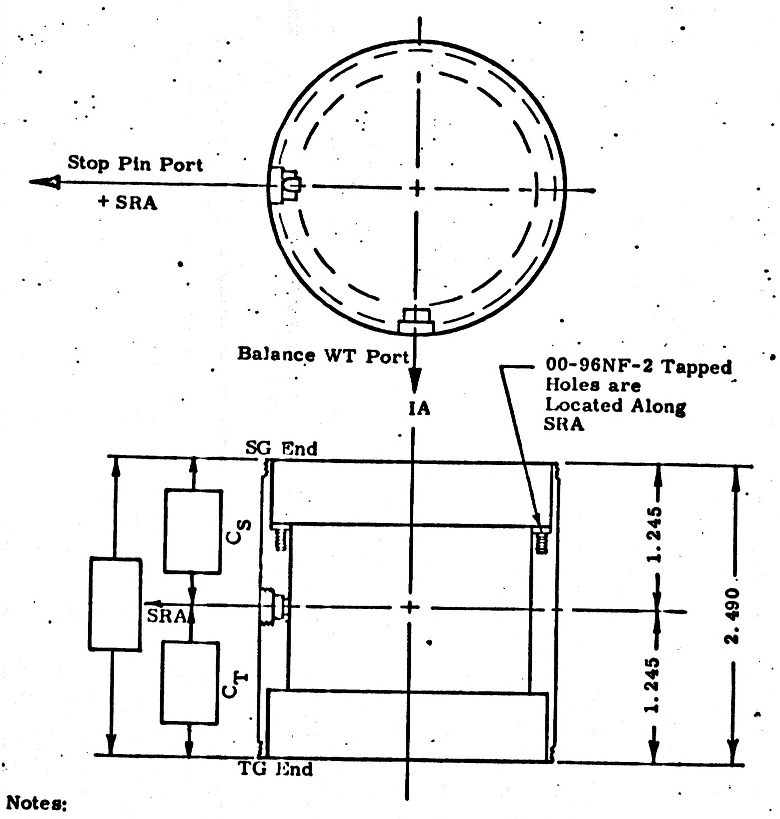
CAMBRIDGE, MASS.
PREPARED BY: C. J. Cormier
DATE: March 19, 1968
MC 25-856
SHEET 2 OF 2



Notes:

1. Measure the dimensions shown (the location of the SRA Balance Port). Record in the blocks provided.
2. All readings to be to 4 decimal places.

IL 27

APOLLO II IRIG Specification
MC 25-887
Release Date ________
Release Revision —
Class A Release
TDRR 35599

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	RBooth	[illegible]
8/1/68	A	36609	1,4	[illegible]	WLS
8/28/69	B	37769	4	EA	MDH

TP#11938

This MC specification consists of page i to ___ and 1 to 4 inclusive.

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

1. ENVIRONMENTAL CONDITIONS 40% maximum humidity

2. CRITICAL AREAS--The critical areas shall be as shown in Figure 1.

3. ACCEPTANCE CRITERIA--The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination of 30 power magnification.

The critical areas of the races shall show a characteristic ground and polished, honed or lapped finish.

The critical areas shall be free from tool marks, chatter waves, grinding scratches, rust, stains, seams, inclusion, and pits, **except as modified by the following:**

a) A pit shall be any imperfection of a size such that the dimension across its major axis is greater than 0.0005 inch. Any imperfections less than this are acceptable.

b) No pit shall exceed 0.0012 inch across its major axis and no two pits shall be closer than 0.012 inch.

c) The maximum number of pits in the critical areas shall not exceed four per part.

d) Scratches, comet tails, grind tears, and cuts running circumferentially in the critical ball track area shall not exceed 0.0012 inch in width, and no raised metal is acceptable.

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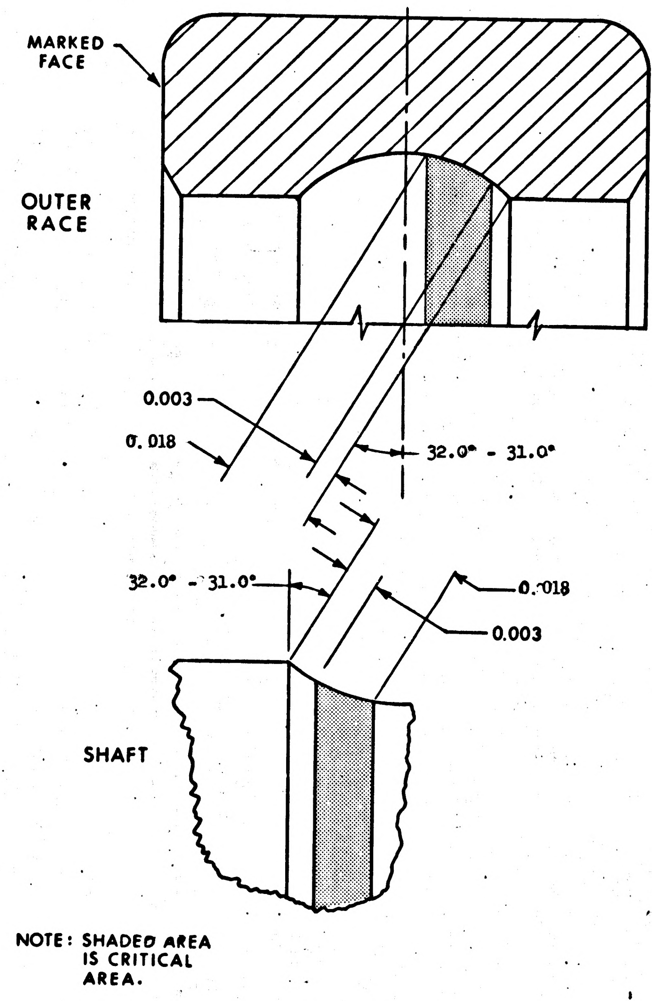


Fig. 1 Critical ball race areas.

---

e) Scratches across the critical area shall not exceed 0.0005 inch in width.

f) No rust shall be present.

4. BALLS

a) The ball luster shall be very bright and the surface matte must be very fine. The following criteria shall determine the acceptability of the balls after microscopic examination under 10 power magnification.

(1) Defects---There shall be no noticeable defects as follows:

(a) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets in excess of .0012 inch width.

(b) Stains and rust - none

(c) Burrs - none

(d) Scratches - 0.0005 inch wide, showing no raised metal

(e) Flats - .0002 inch maximum width

5. Non critical Areas. - Non critical areas shall be all those not covered by the requirements of Paragraphs 2 and 3.

a) Acceptance Criteria. - The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination under 10 power magnification.

Defect	Ground Surfaces	Chamfers, Undercuts, Threads and Machined Bores
(1) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets	.0003 inch	None which affect dimensional tolerances.

(2)	Stains, rust	None	No rust. Stains are acceptable.
(3)	Burrs,	None	None which affect dimensional tolerances.
(4)	Scratches	None which affect dimensional tolerances	None which affect dimensional tolerances
(5)	Flats	None which affect dimensional tolerances	None which affect dimensional tolerances

6. Contact angle determination - All necessary components of the contact angle shall be measured in accordance with the following formula to determine the contact angle:

$$\text{Cosine } \beta_o = \frac{E}{d}\left[1 - \left(\frac{2 N_E}{N_i}\right)\right]$$

where E = pitch diameter of 0.249450(print nominal value)
d = average ball diameter of row (vendor supplied information)
N_E = number of revolutions of the retainer
N_i = Number of revolutions of the inner race
β_o = contact angle

APOLLO II IRIG Specification
MC 25-858
Release Date October 30, 1968
Release Revision A
Class 1 Release
TDRR 14531

Title: Microsyn Processing

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/29/68	B	36389	1, 2, 3	PRK	

TP#11938

This MC specification consists of page 1 to____and 1 to 3 inclusive.

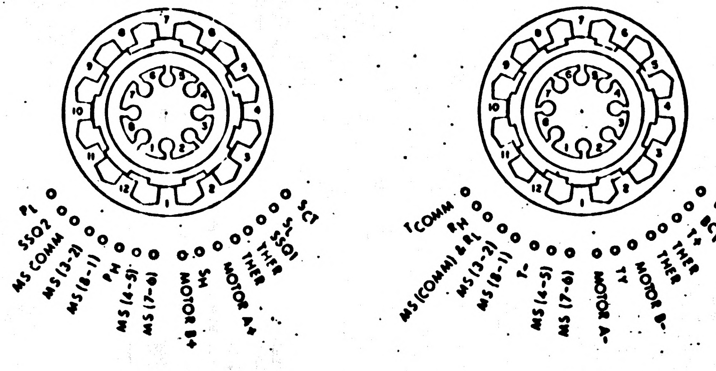
TDRR 36389 JUNE 27, 1966

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS

PREPARED BY C. J. Cormier
DATE April 16, 1968
MC 25-858
SHEET 1
OF 2

APOLLO II IRIG MICROSYN PROCESSING

UNIT#



S G. END
LKG. TOWARD FLOAT

T. G. END
LKG. TOWARD FLOAT

Rev A 10-30-64

	EXPECTED RESISTANCE		RESISTANCE AS RECEIVED		RESISTANCE AFTER ASSEMBLY		RESISTANCE AFTER POTTING		RESISTANCE AFTER CYCLING		RES. AFTER FINAL GRIND		RES. BEFORE FINAL ASSEMBLY	
MICROSYN STATOR ASSEMBLY S. G. END														
P_H TO P_L	23													
S_L TO S_H	46													
S_H TO SSO1	8													
S_H TO SSO2	12													
S_H TO S_{CT}	23													
INNER SUSPENSION	T.G.	S.G.	T.G.	S.G.	T.G.	S.G.	T.G.	S.G.	T.G.	S.G.	T.G.	S.G.	T.G.	S.G.
MS(3-2) TO COMM ⏚ MS(4-5) TO MS(7-6) TO MS(8-1) TO	30Ω	30Ω												
MICROSYN STATOR ASSEMBLY T. G. END														
T+ TO TY	92													
T- TO TY	92													
T COMM TO TY	92													
BC_1 TO BC_2	0.8													
R_H TO R_L	48													
Megger 250 volts DC														

IL 27

TDRR 14531 NOV 25 1964

TDRR 36389 JUNE 27, 1966

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: April 16, 1968
MC 25-858
SHEET 2
OF 2

1. Post-cure 40 hours at 212° ± 5°F under 30" Hg vacuum ( )
2. Cycling Procedure. ( )
   Cycle four times 0°F to 180°F at a maximum rate of 3°/min. with a dwell time of one hour at the extremes. ( )
3. Resistance check (Ohmmeter): Continuity ( )
   Grounds ( )
   Record ( )
4. Check for cracks.

Alternate. Cycle:
Cycle four (4) times 0°F to 200°F at a maximum rate of 4°/minute, with a dwell time of one (1) hour at the extremes.

IL 27

r.C.

APOLLO II IRIG Specification
MC 25-880 REV C
Release Date 8 FEB 68
Release Revision —
Class A **Release**
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
8 FEB 68	—	35585	INITIAL RELEASE	R B[illegible] 2-7-68	—
8/1/68	A	36624	All, except 8, 20, 24.	B Ro[illegible] 9-17	—
1/21/69	B	37228	20	MGM EA	WLS
1/31/69	C	37287	10	[illegible] MGM EA	WLS

TP# 11935

This MC specification consists of page 1 to ___ and 1 to 24 inclusive.

APOLLO II WHEEL PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo II wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer (C-2021816) shall be packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per (MC 25-878). Check and inspect the bearing surfaces. No defects will be accepted on balls and critical areas of inner and outer races as defined by fig. 1 (MC 25-887) (e.g., corrosion, brinelling, burrs, stains, gage marks, raised metal, tears, cuts, scratches, stringers, nicks, dents, digs, gouges, comets, pits, and inclusions). Check for oil wettability per (MC 25-890).

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurements. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurements are made and record this information together with the average O.D. measurement on (MC 25-886). Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para 7.

1.5 Reclean the outer race per (MC 25-878) as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. The oil shall be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
Quick Seal type 150 Natl. Inst. Co., Baltimore, Maryland
Master Gage Plugs, Class XXX (.180000-.180020)
Sheffield Air Ring with two small jets for measuring the (.180000-.180030) diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring (.3748-.3749) diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749, .3750, .3751)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2.0 INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC 25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture (B-87392).

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F, immerse wheel hub into liquid nitrogen until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps 2.6 through 2.8.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve (A-87392.5) and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press
Simpson Model 388 thermocouple indicator or equivalent.

3.0 TEMPERATURE CYCLING

3.1 Place in a suitable closed glass container.

3.2 Place in the cycling container, (2A3-10B177) Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and +200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber

4.0 LAPPING BEARING BORES

NOTE: Insure that all finished 0-80 tapped holes of hub element have been lapped.

4.1 Measure the lapping room temperature and using the wheel assembly data

sheet (MC 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator or Cleveland Indiron should not exceed 20 microinches, and should not extend more than .050" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (MC 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150° ± 5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
    Model 153-40 used with small jet spindles and Class XXX
    Master Gage Rings
Hand Lap-3/8" dia. x 3" long-American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Co., Inc.
Zeiss Stereo Microscope or American Optical
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner
Cleveland Indiron

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5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries inc.,
Sycamore, Illinois

6.0 'B' DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.976000 gage block and the Johansson Mikrokator S 510- E-8, measure accurately (to within 5 microinches) dimension 'B' and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment

C. E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per (MC 25-878).

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used. Insure that interference is reduced to a minimum by predenting the ball pockets, This should eliminate possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

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measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture (D-95850). Rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\cos\beta = \frac{E}{d}\left[1 - 2\frac{N_e}{N_i}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on (MC 25-886.)

Equipment
Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension 'A' as recorded on bearing package by manufacturer, and dimension 'B' as measured in section 6, determine spacer thickness by using the following formula:

A = B + t-65 microinches
or t = A - B + 65 microinches

where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

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9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 20 microns minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE

9.2.1 Centrifuge retainer for 15 ±1 minutes at 9000 ± 150 G's one side only.

9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.

9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 20 microns minimum.

9.2.4 Remove retainers from oven and weigh immediately.

9.2.5 Compute oil retention of each retainer as follows:

$$\%\ \text{retention} = \frac{W_1 - W_o}{W_0} \times 100$$

where W_0 = weight of dry retainer

W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.
If oil retention is outside specified retention range, retainers may be re-soaked in oil and/or recentrifuged varying the times to achieve the specified retention limits.

9.2.6 After retainers are impregnated, O.D. of retainer, pocket diameter and pocket alignment shall meet tolerances shown on (Dwg. C-2021817).

9.2.7 Store retainers in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

9.2.8 General Notes:

9.2.8.1 Retainers should be handled with bone tweezers or gloves to minimize moisture absorption and contamination.

9.2.8.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.7 above.

9.2.8.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ± 5°F and 20 microns minimum, outgas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for 18 hours minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6 above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies (2A3-10A187-1) or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ± 5°F allowing 15-20 minutes for temperature to stabilize.

10.3.1.2 Remove from oven and install assemblies into centrifuge plate (2A3-10C187-1), or equivalent, and spin for 10 minutes ± 1/2 minute at 4000 ± 100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Remove from centrifuge and blot retainer edges with lens paper. Place retainers in oven at 150° ± 5°F for 3 to 6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percentage (%) absorption of individual retainers as follows:

$$\%\ \text{absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 After recording weight and percentage retention, place in pyrex dish using desiccants to minimize the humidity of the storage environment

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet may be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per (MC 25-878.)

11.3 Clean wheel inertial element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ± 5°F and evacuate for one hour minimum at 29.5"Hg vacuum maximum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Prior to assembly, the balls may be prelubricated as follows:

Mix 500 parts of Freon to 1 part of oil in a beaker and immerse the balls. Vacuum dry the balls and examine them under a 25X - 30X microscope making sure that the balls are clean.

Assemble retainers, balls and outer races as follows:

12.1 With fixture (A-118577) assembled, place outer race with stamped end up on shoulder of fixture (A-118579).

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture (A-118578).

12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer. Inspect carefully with 25x to 30x microscope for contaminants.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy (A-118577)

12.5.1.1 Fixture (A-118579)

12.5.1.2 Fixture (A-118578)

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture (A-88948.3) with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with stainless steel tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer (C-202170)" over the bearing and use fixtures (A-88948.1) and (A-88948.2) to press into the bore. The force necessary to push the bearing into the bore will be in the range of 2-5 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight. NOTE: Insure that all threads of 0-80 have been lapped prior to assembly.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Place corresponding end of shaft upward on shaft holding fixture ass'y (Dwg. 166042). Hold element with installed bearing and install on shaft. Using wheel holding fixture (Dwg. 166045) install on top of element. Invert entire fixture ass'y so that wheel holding fixture (Dwg. 166045) becomes the base and carefully remove shaft holding fixture (Dwg. 166042).

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture (A-88948.1 and (A-88948.2) to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements).

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen head screws .187 long. NOTE: Insure that all threads of 0-80 Allen head screws have been lapped to remove burrs and smooth down rough edges. Assemble protective cap (Dwg. 166037) before using Allen wrench to adjust 0-80 screws.

Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without placing any preload on the bearings.

13.13 Inspect with microscope at 30X heads only of 0-80 screws for loose particles of metal.

13.14 Remove dust protector if necessary prior to shaft strain.

14. SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter (A-92246.1) to the #2 end with the flat end inward and tighten to a torque of 0.75 in.lb (strain gage measurements at MIT indicate that 0.75 in.lb of torque produces 76 microinches/inch shaft strain and a corresponding 65 microinches shaft deformation). The 65 microinches shaft deformation will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION(Preload Fixture D-92272)

15.1 Assemble shaft adapter (A-92278) to the #2 end of wheel.

15.2 Assemble shaft cap (A-92277) to the #1 end of wheel. In assembly of these adapters care should be taken so that the applied torque does not exceed 0.75 in.lb.

15.3 Preheat wheel in oven at 150° ± 5° for 15 to 20 minutes. Remove wheel from oven and hand rotate shaft in one direction a sufficient number of times to prelubricate raceways and balls. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an additional 25-30 minutes and repeat prelubrication procedure. Once prelubrication is achieved, inspect bearings for contamination and repeat step 13.13

15.4 Allow wheel to return to room temperature and position wheel on top plate (C-94190). Assemble weight pan (A-92281) with a 1 lb. weight.

15.5 Carefully inspect clamping ring (C-94185) on top of wheel insuring that delrin washer (A-94186) contacts wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan (A-92281) to chain hanging from shaft adapter (A-92278).

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying a three pound load. Lift the weight, zero the meter, and then gently apply the three pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

Note: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap (A-92277). Maximum axial runout of shaft cap is 10 microinches with ±45° rotation.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft ±45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ±10 microinches the proper preload has been achieved. Unload bearings and repeat steps 15.8 thru 15.11 to ensure return to reference within the ±10 microinches. If repeatability is not achieved change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and record the displacement of the indicator from zero for each weight in (MC-811). These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on (MC-811).

15.14 Before preliminary dynamic balancing, position of cap, (Dwg. C-2021669) shall be checked with cap centering ring (A-92244). Remove socket head screws on number one end of wheel and replace with final 0-80 screws.* Inspect at 25x to 30x for possible contamination of bearings. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)

16.1 Attach thermocouple wire with calibrated Alnor meter to center of OD of stator housing.

*NOTE: All threads of 0-80 screws shall have been previously lapped with Lapping compound [illegible]-1200-US Products Co.

Cover stator housing and entire rotor platform with heater blanket of chromalox 630-2, 115 volts, 25 watts (R62) or equivalent. Place wheel in oven to preheat for approximately 30 minutes minimum at 150°F and at the same time preheat the rotor platform until Alnor meter indicates 140°-145°F. Remove wheel from oven and place in dynamic balancer. Increase the gain on amplifier until wheel just starts to rotate, note the voltage, and back off immediately. This is the breakaway voltage. NOTE: If breakaway voltage exceeds 16.5 volts check for retainer rub, high preload, etc. Increase amplifier gain to 28 volts. The wheel will rotate at synchronous speed and temperature will increase. At this speed the rotor platform temperature should be reset to 140°-145°F as indicated by Alnor meter.

16.2 Dynamically balance the wheel until the residual unbalance is no greater than "0.10 dyne-cm at 12,000 rpm." Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with delrin caps, Dwg. No. B-166037 to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope after each increment of balance. Visually inspect under 25x to 30x for contamination or physical change in bearings. Remove any trace of contamination.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 ~~Place in a suitable closed glass container~~ the cycling container, 2A3-10B177.

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.
Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.
Alt. Cycle: 32°F to 180°F

Equipment

Cycling Container; Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

19.1 Remove wheel from the dynamometer and place it in stand (A-88948.3). Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten with 11 to 13 oz. in. of torque. Care should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per(MC 25-304) may be used as an alternative material to tack screw heads.

19.2 With a microscope examine the area around the screw head and wipe off off any excess Loctite. (Loctite will not cure if exposed to air).
Repeat this procedure to all 8 screws.

19.3 To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures (A-88948.3),(A-92244)
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant type A
   American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per(SCD 2021552)

20 DYNAMIC BALANCING (Final)

20.1 Place the wheel in oven to preheat for 30 minutes minimum at 150°F. Remove wheel from oven and place in dynamic balancer. With amplifier gain adjusted to 28 volts, check the final balance of the wheel and make necessary corrections to achieve maximum residual unbalance of 0.10 dyne-cm at 24,000 rpm.

NOTE: This check should be made with the wheel at operating temperature as follows:
The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.

2) Cover the stator housing and entire rotor platform with heater blanket chromalox 630-2,115 volts,. 25 watts,(R62) or equivalent.

3) Run the wheel at synchronous speed until the Alnor meter indicates 140°-145°F.

Equipment

Micro Dynamic Balancer, Model K-1
  Micro Balancing, Inc.
  Garden City Park, Long Island, New York
  (includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
  Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

21.2 Clean off with vacuum hose and repeat 21.1.
21.3 Record final weight of wheel on(MC 25-811)(MC 25-628)and(MC 25-605).
21.4 Place the wheel in a covered glass container and store in moisture free atmosphere.

Equipment

Zeiss Stereo Microscope } or Equivalent
Vacuum hose

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure (MC 25-855)

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter (A-95721), firmly to the VS-10.

22.2 Thread lock-nut (A-92357) to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter (A-95721) very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut (A-92357) firmly against the bushing, using spanner wrench (A-92359).

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 25-50 mv. At this drive voltage the acceleration level of the float is less than 2 g's.
IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V.T.V.M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on(M.C. 811) within ± 0.25 microinch/lb.

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22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on(MC ·-811) insert wrench (A-92262) in the + SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench (A-92262), and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on(MC 25-811) insert wrench (A-92262), and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in(M.C. 25-605)

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 3.0 microinch/lb. If the term ΔC is greater than 1.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4°/ min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in(MC ·-811). If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

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22.14 Using a spade oiler, or other suitable tool, apply LCA-9, (SCD 2021529) (MC 25-302) to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14. Replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on(MC 25-605)

22.19 Refer to(MC 25-855)for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder (2A3-10A180-1.2) with the Fenwal Thermistor probe. into one of the IA balance ports.

23.2 Install the float into fixture (C-87364) and attach power and thermistor leads onto provided terminal strip.

23.3 Install top plate (A-87364.1) on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 135°-140°F. With wheel at 135°-140°F turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per(MC 25-882)

24. DELIVERY

Continue float assembly per(MC 25-855)

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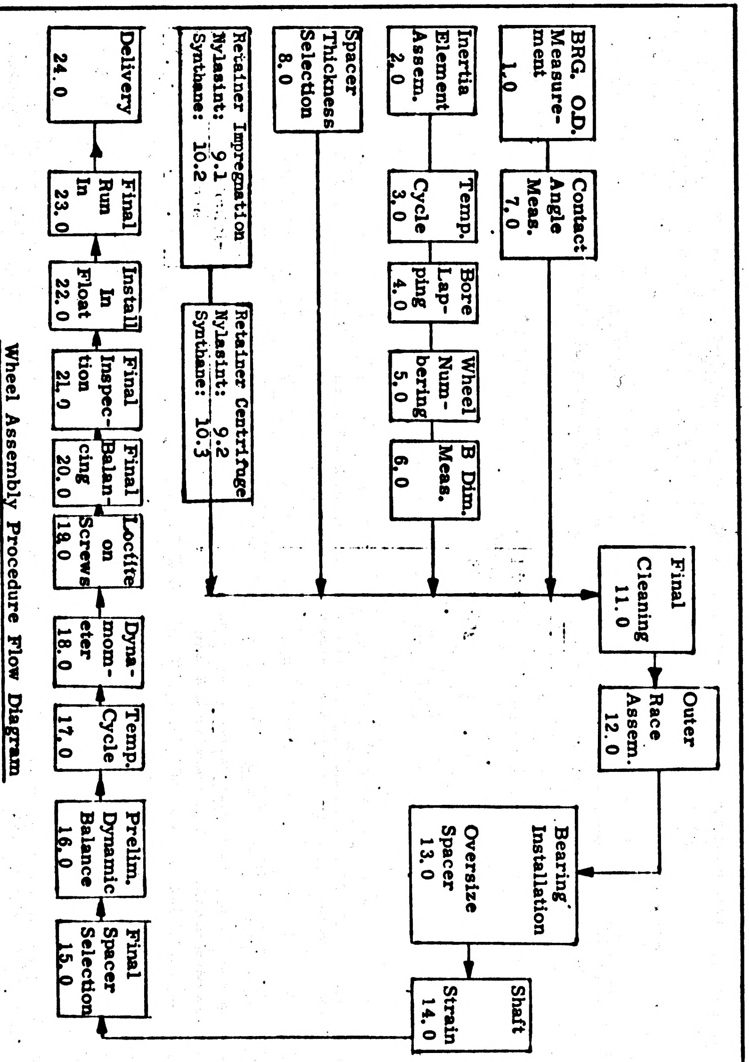
BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation Nylasint: 9.1 Synthane: 10.2
Retainer Centrifuge Nylasint: 9.2 Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Locfite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

Fig. 1

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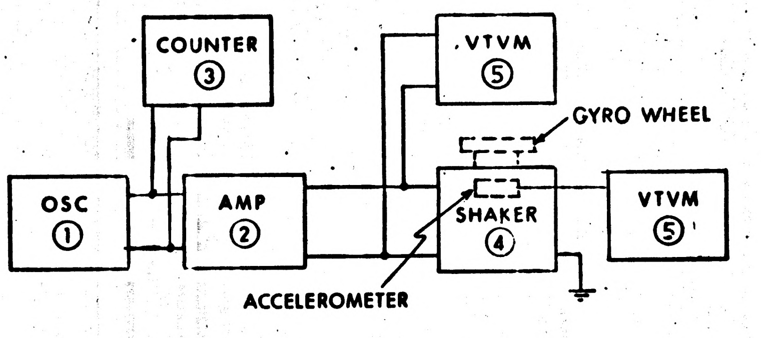
Compliance Checking Equipment
Apollo 2 Gyro


COUNTER ③
VTVM ⑤
GYRO WHEEL
OSC ①
AMP ②
SHAKER ④
VTVM ⑤
ACCELEROMETER

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. [illegible]

Fig 2

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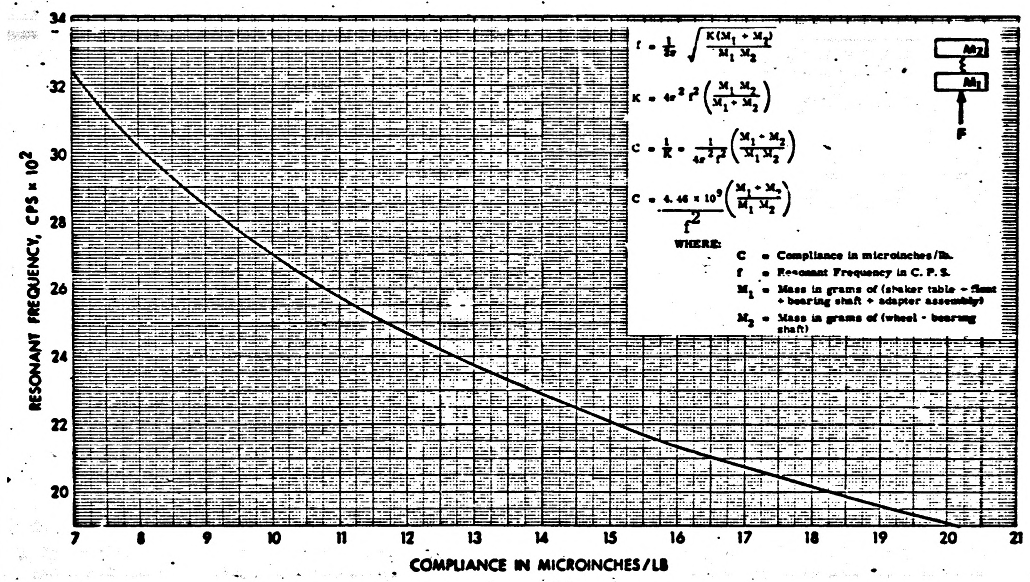

$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.

f = Resonant Frequency in C. P. S.

M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)

M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

FIG 3

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APOLLO II IRIG Specification
MC 25-881
Release Date ________
Release Revision __–__
Class __A__ Release
TDRR __35599__

Evaluation of Apollo II Wheel in Dynamometer

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	R Root	WJJ
8/1/68	A	36606	ALL	PRK	--
11/20/68	B	37035	Page 2	PRK	--
8/28/69	C	37772	4,5,6	EA	MDH

TP#11938

This MC specification consists of page 1 to____and 1 to 15 inclusive.

EVALUATION OF APOLLO II WHEEL IN DYNAMOMETER

1.0 General Requirements

The initial wheel evaluation will be made over a 200 hour qualification period using rundown time measurement, breakaway voltage measurement, minimum voltage to synchronous speed and torque monitoring as the critical parameters. During qualification,,wheel shall be operated in ambient of one half atmosphere of helium. Alternate: 5.0 psig helium. Prior to setting ambient, dynamometer fixtures shall be evacuated to 20 in. mercury vacuum and back filled with helium to one atmospnere. Repeat evacuation and backfull five times minimum.

1.1 Rundown Time Measurements

The wheel qualification rundown time measurements shall be taken twice in each 24 hour period with a minimum of four (4) hours between rundowns. After the first 50 hours of wheel qualification a minimum of one rundown time measurement may be taken in each 24 hour period except on weekends or holidays. The total number of rundown time measurements shall not be less than 12. To measure rundown time, switch off wheel momentarily to dissipate any overexcitation and proceed per MC 25-834. Wheel operating temperature, and other rundown data shall be recorded on MC-811.

1.2 Breakaway Voltage Measurements

The wheel qualification breakaway voltage measurements shall be made per (MC 25-873) once every 24 hours during the qualification period. Record data on MC-811.

1.3 Minimum Voltage to Reach Synchronous Speed

The wheel must be capable of reaching synchronous speed at 26.6 volts. Minimum voltage measurements shall be made once every 24 hours during the qualification period. Record data on MC-811.

1.4 Torque Monitoring

The wheel qualification torque monitoring recording shall be performed during the entire 200 hour qualification period for acceptable wheels. Refer to MC 25-888 for the wheel qualification equipment specification. The recording shall be continous except for interruptions due to scheduled rundown time measurements and interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Disposition Points

There are two formal points in time for making wheel dispositions, namely the fiftieth and the two hundredth hours of wheel operations. Fig. 1 serves to clarify the use of these formal disposition points and indicates a wheel qualification program yield history. Dispositions at points other than the 50th and 200th hour are allowed but not required.

2.1 Fifty Hour Disposition

Within 24 hours after the completion of the first 50 hours of wheel qualification a disposition shall be made using the following criteria.

2.1.1 Rundown Time Repeatability

If the maximum difference between the four (4) rundown time measurements is greater than 10 seconds, two more measurements shall be taken at 15 min. minimum intervals to determine if rundown time is bad or if level is actually changing. Final disposition shall be made after 200 hours using all rundown time measurements (See para. 1.1).

2.1.2 Torque Monitoring Performance

The criteria for acceptance in the dynamometer evaluation lies in the interpretation of the recorded trace taken between each rundown time interval. In order to provide objectivity in this interpretation reference will be made to a number of characteristic forms of the dynamometer trace and specifications or limits imposed on each. The following identification pertains to dynamometer traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.
To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.1.2.1 Acceptable Torque Trace

The principal requirements for an acceptable wheel is performance during the monitoring period that is free of non-periodic or step torque variations greater than 75 dyne-cm. Fig. 2a,b,c represent acceptable torque traces with 2b and 2c indicating acceptable periodic variations. (The variations are due, in this

---

case, to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 150 dyne-cm. The maximum allowable variation in trace width during the total wheel monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period compared to the level exhibited during the period between the fifth hour of running and the first wheel rundown. The allowable increase is as indicated below.

5th Hour to 1st RDT Average Dyna. Torque	Allowable Maximum Trace Width at Any Time Average Dyna. Torque
25	75
50	100
75	100
100	125
125-150	150

2.1.2.2 Provisionally Acceptable Torque Trace

There are two categories of torque variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.1.2.2.1 Torque Level Disturbance

Fig. 3a is typical of torque trace exhibiting a disturbance of the torque level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than once during the 50 hour qualifying period as shown in Figure 1.

2.1.2.2.2 Test Equipment Influences

Fig. 3b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory torque trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller than this component of the torque trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

APOLLO II IRIG Specification
MC 25-861C
Release Date 25 Nov., 1965
Release Revision A
Class A Release
TDRR 14531

ASSEMBLY PROCEDURE FOR MICROSYN

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
3/18/65	B	17643	1, 2, 3	WK.	WJ.C
4/21/68	C	36023	2, 3	P.K.	

This MC specification consists of page 1 to____and 1 to 3 inclusive.

TP#11938

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964
MC 25-861
SHEET 1
OF 3

ASSEMBLY PROCEDURE FOR MICROSYN APOLLO II IRIG

1.0 Coils

1.1 Assemble arbor A-104296 and coat with mold release. (DC 20 or equivalent)

1.2 Winding directions and number of turns are found on coil drawings.

B 1.3 Wrap two layers of lens tissue around arbor. Wind coil dry. Add two layers of lens tissue between windings on the double-wound coil assembly.

1.4 Secure last lead.

1.5 Straighten leads and cut to length.

1.6 Impregnate coils per MC-25-501.

1.7 Remove coils from arbors.

1.8 Inspect per print.

1.9 From a group of at least 50 coils, select one to use as the standard coil. Measure the percent impedance deviations (plus and minus) of the primary and secondary of all other coils relative to the standard.

Compare coils in air at 10 kcps on a comparison bridge, selecting coils within a 1% span for a microsyn assembly (Fig 1).

1.91 The double-wound coil A and B windings should be checked and impedance differences plotted A vs. B. (Fig 2). Selection of eight coils should be made in a 1% square.

Rev B 3-18-65
Rev A 10/27/64

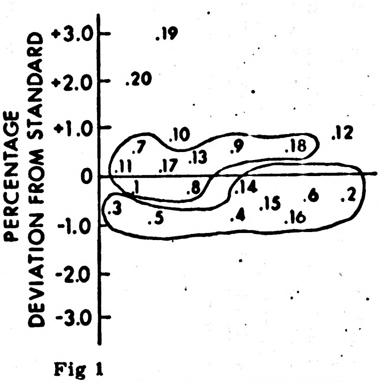


Fig 1

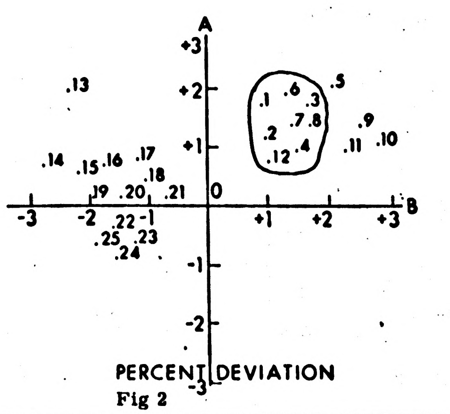


Fig 2

TDRR 14531 NOV 25 1964

TDRR 36023 APR 21 1968

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964
MC 25-861C
SHEET 2
OF 3

2.0 **T. G. Microsyn Assembly 2021656**

2.1 Wash stator core, printed circuit, and insulator by immersing in Ethyl Alcohol for 3 minutes and freon for approximately 10 minutes in ultrasonic cleaner.

2.2 Bond insulator and printed circuit to Durafilm side of stator core with Epon 828 per MC 25-303. Use fixture C-127576.

2.3 Place Assy. in oven and cure at 150°F for $1\frac{1}{2}$ hours.

2.4 Remove Assy. from fixture.

2.5 Place coils on stator core. Determine lead length and strip with X-Var.

2.6 Solder coil leads to pads using 60-40 solder and Kester 1571 flux. Remove flux using Kester AP-20 and acid brush or cotton swab.

2.7 Wash assembly in Ethyl Alcohol for 3 minutes and freon for 10 minutes in ultrasonic cleaner.

2.8 Check continuity, polarity, and insulation test 250VDC, 500 megohms minimum.

2.9 Hold coils back with Durofilm coated Tru-Arc rings (A-82875). Perform insulation check again.

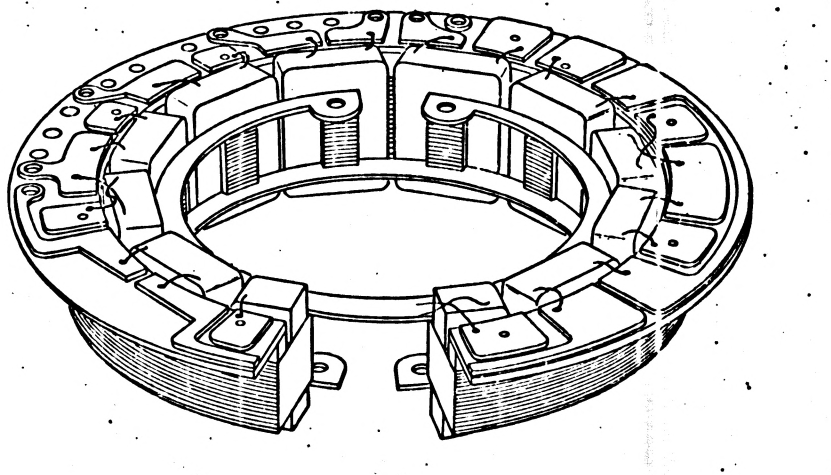


Figure 3

TDRR 36023 APR 21 1968

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964
MC 25-861C
SHEET 3
OF 3

B 2.10 Cement coils in position with Epon 828 cement (MC25-303). Cover coil lead wires with a thin coat of Epon 828 cement.

2.11 Place assembly in oven and cure at 212°F for 1 hour.

2.12 Place tapered wooden sticks between coils 12 and 1 and between coils 1 and 2 to support reset coil while winding. Repeat for the rest of the reset coil winding. Wind reset coils.

2.13 Cut and form 0.005 Spaldo paper to fit between coils 2 and 3, 5 and 6, 8 and 9; and 1 and 12 to support winding.

2.14 Check for continuity, polarity, and grounds.

2.15 Remove one wooden stick at a time. Using thread, tie a slip knot around reset winding between coils where stick was removed and draw up to contain coil. Continue above procedure. Check 0.440 dimension.

2.16 Solder reset leads to pads using 60-40 solder and Kester 1571 flux.

2.17 Wind bias coil on Pole #9 as shown in 2021656. Solder lead ends to pads using 60-40 and Kester 1571 flux.

2.18 With an eyedropper flow Methyl Cellosolve over reset and bias coil. (Methyl cellosolve is used for solvent bonding.)

A 2.19 Place assembly in oven and cure at 212°F for 1/2 hour.

2.20 Remove assembly from oven, let cool, remove thread (see 2.15) and Spaldo paper (see 2.13) then wash by ultrasonic cleaning for 10 minutes in virgin filtered Freon.

2.21 Check unit for continuity, size (0.440 Dim), and insulation test. 250 volts DC500 megohms.

A 2.22 Weigh out 25 Grams of Silastic #881 (Dow Corning) and 1.0 Grams of Activator #881 and mix thoroughly.

A 2.23 With a suitable applicator, apply a very thin coat of the silastic to the I.D. of the microsyn stack between the poles. See figure 4. Cure for 2 hours at 160°±5°F or overnight at room temperature.

2.24 Store unit carefully for future use.

3.0 **S.G. Microsyn Assembly 2021664**

Same as T.G. except omit steps 2.12 through 2.21.

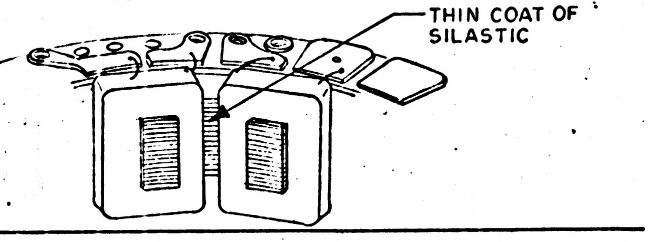


Fig. 4

2.1.2.3 Oil Jogs

Fig. 3c is a typical torque trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 720 dyne-cm-minutes, the wheel shall be rejected.

NOTE: The procedure for calculating the area of oil jogs is as follows:
Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area illustrated in Figure 5.

2.1.2.3.1 Modulation of Oil

If area of oil jogs are greater than 720 dyne-cm minutes then remove oil from retainer by following procedure: Use 2 dry baked retainers. The retainers shall be weighed immediately upon removal from 150°F oven. Record weight. Place retainers on shaft of wheel and slide up against bearing retainer and hold in positive contact. Bake in (150°-160°F) oven for one hour (period of time reference only). Remove one retainer at a time from wheel while still in oven and weigh quickly. Subtract first weight from second weight to determine amount of oil removed. The procedure may be repeated if oil jogs are still excessive.

2.1.2.4 Non Acceptable Torque Trace

Any torque trace resembling Figs. 4a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are squeal (Fig. 4b) intermittent squeal (Fig. 4a), low preload (Fig. 4b,c), incipient varnish failure (Fig. 4b, c, d, e, f) debris (Fig. 4b, d, e) loose wires (Fig. b, c), one ball group unstable (Fig. c, h) equipment malfunction Fig. 4i.

2.1.2.5 Retainer stability motion study

The following procedure is recommended as a retainer stability motion study and may be used either before or after dynamometer evaluation. If a wheel is rejected because of non-acceptable torque trace, retainer motion shall be observed to assist in determining reason for wheel failure. Place wheel in milliwattmeter fixture (Dwg. E-159826). Wheel shall be operated in ambient one-half atmosphere or 5 psig

and at operating temperature (137°F). Run wheel up to synchronous speed. Adjust binocular microscope (American Optical or equivalent) to 10 power and focus on one of the retainers of running wheel. With variable oscillator, externally trigger stroboscope with sufficient excitation to fire stroboscope and electronic counter. Set oscillator at retainer frequency (Ref. 243 Hz) and aim stroboscope at bearing as close as possible. Adjust oscillator until retainer appears to "stop" and observe stability of motion. Continue observation with retainer slowly drifting for possible signs of erratic behavior. Repeat observations with second bearing. If retainer shows instability of motion it shall be replaced.

2.1.2.6 Other dynamometer requirements

The maximum variation in mean torque level shall not exceed 200 dyne-cm. The minimum allowable torque level shall be 800 dyne-cm (normal range 800-1800 dyne-cm, reference only)

2.2 Two Hundred Hour Disposition

After a minimum of 200 hours of wheel qualification a disposition shall be made using the following criteria.

2.2.1 Rundown Time

2.2.1.1 The RMS of all wheel rundown times (σ_D) shall be equal to or less than 3 seconds.

2.2.1.2 The RMS of the wheel rundown time (σ_D) shall be calculated using the following

$$\sigma_D = \sqrt{\frac{(T_1 - A_D)^2 + (T_2 - A_D)^2 + \ldots\ldots (T_n - A_D)^2}{n}}$$

A_D = Average run-down time to 6000 rpm
n = Number of run-down checks (no less than 12)
$T_1 \ldots T_n$ = Run down time to 6000 rpm

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the wheel assembly.

2.2.2 Breakaway Voltage Measurement Comparison

Breakaway voltages measured during wheel qualification period should be examined. Although no specification requirement is imposed herein, this information should be examined along with the rundown times and torque traces. Like decreasing rundown times, a significant increase of breakaway voltage is indicative of incipient bearing failure.

2.2.3 Torque Monitoring Performance

The criteria of section 2.1.2 are to be applied to the 200 hour disposition.

2.2.4 Synchronous Voltage Measurement Comparison

Minimum voltage to reach synchronous speed at the beginning and end of the wheel qualification period should be compared. This information should be examined along with breakaway voltage measurements, rundown times and torque traces for any indication of incipient bearing failure.

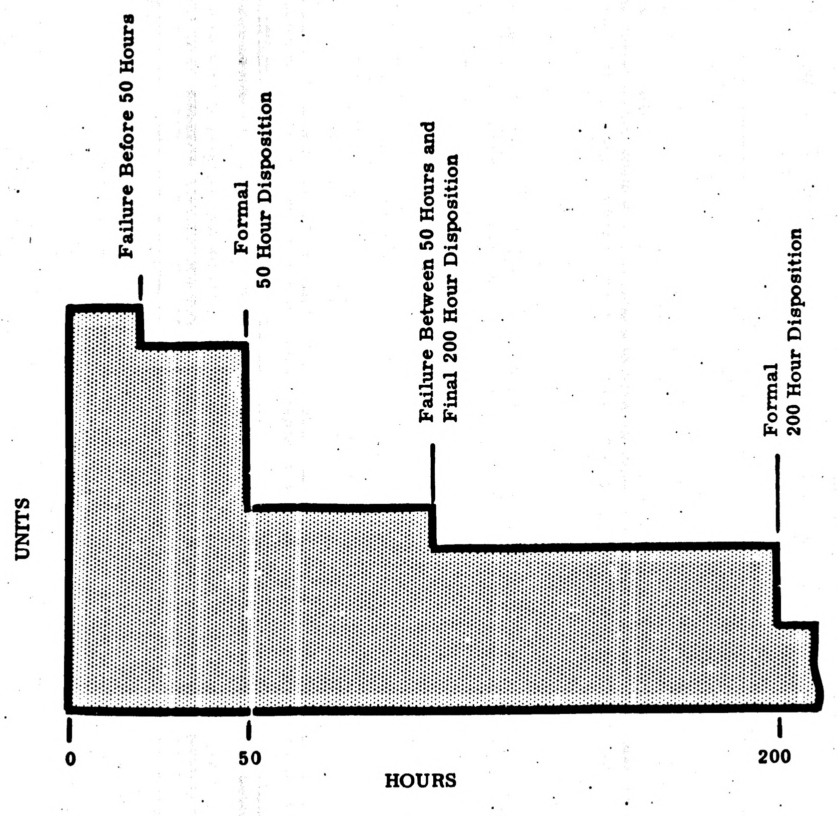
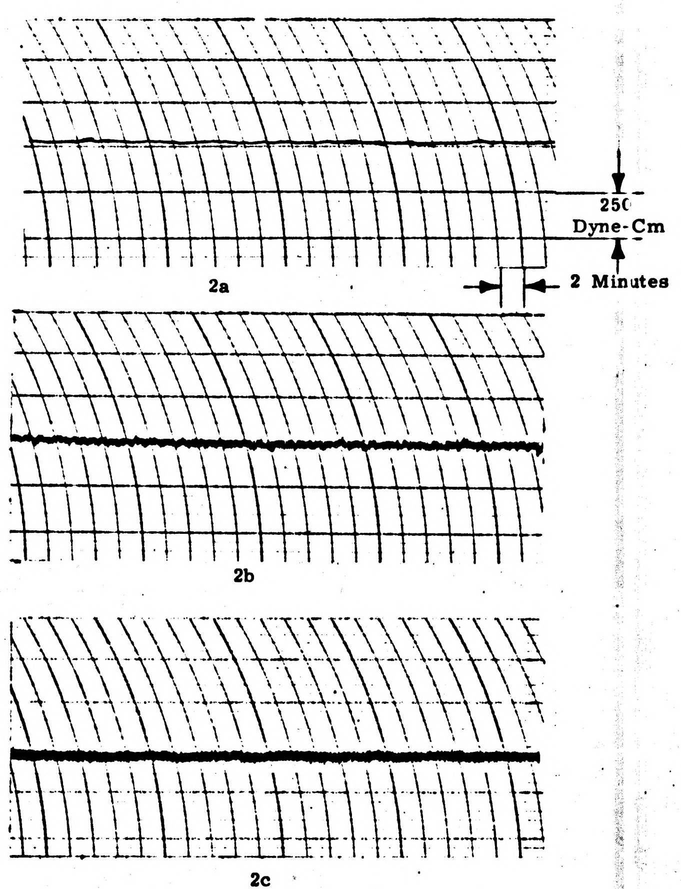


Fig. 1 Illustrative Wheel Qualification Program Yield History.



2a

2b

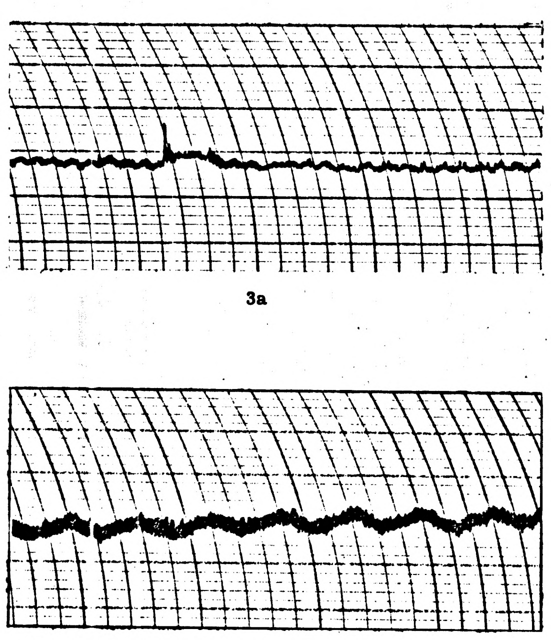
2c

Chart Speed	6 inches/Hour
Recorder Calibration	25 D.C./mm
Recorder Time Constant	0.3 sec ± 15%

*

Fig. 2 Acceptable Torque Traces

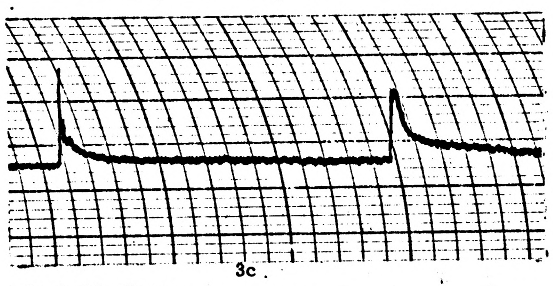
* Chart information applicable to figures 2, 3, 4,



3a

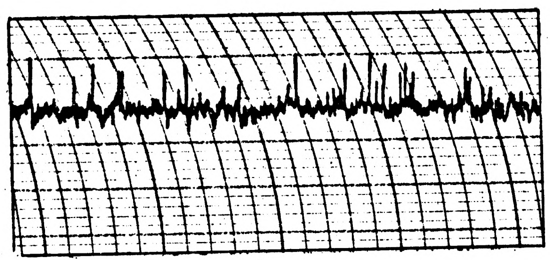
3b

Fig. 3 Provisionally Acceptable Torque Traces



3c

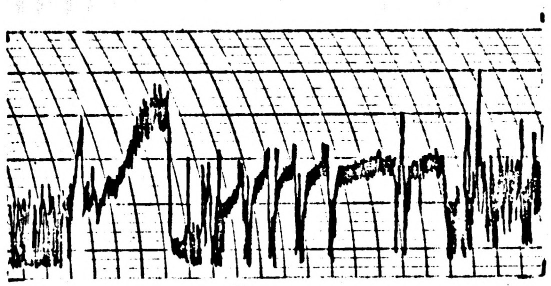
Probable Cause	
Oil jog	Instantaneous torque increase and gradual decay caused by an excess of lubricant being thrown into the ball track.



4a

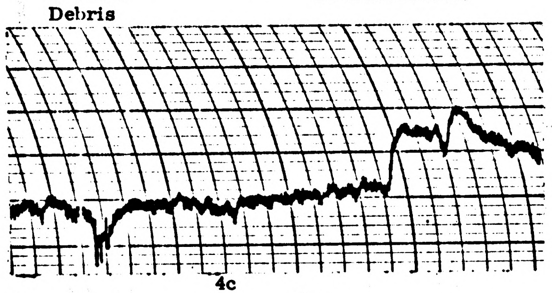
Probable Cause	
Excessive Oil Intermittent Squeal	Instantaneous torque increase caused by the retainer superimposed on a rough and irregular power trace.

Fig. 4 Non-Acceptable Torque Traces.



4b

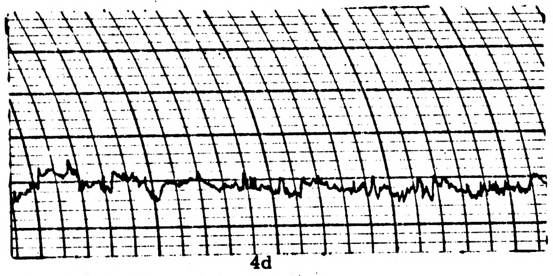
Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular torque trace that could be attributed to any or all of the listed causes singly or in combination.



4c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 4b.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

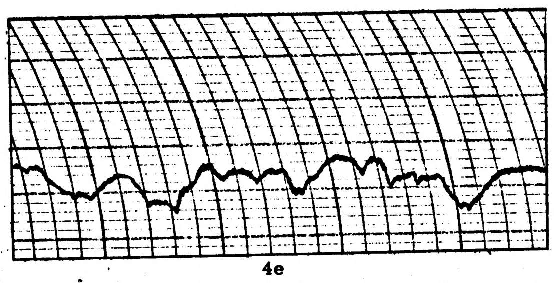


4d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced torque variation.



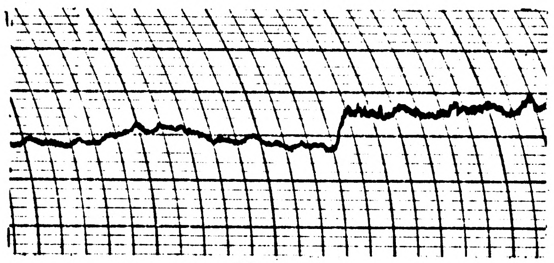
4e

Probable Cause

Varnish
Debris

A torque variation induced by debris or varnish, not as common as 4e but a positive indicator of an incipient failure.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

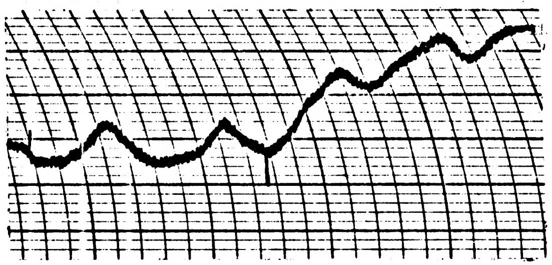


4f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



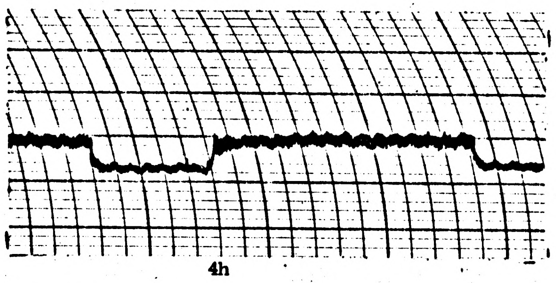
4g

Probable Cause

Varnish

This trace shows a steady increase in torque with a superimposed sinusoid attributable to a temperature control cycle.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

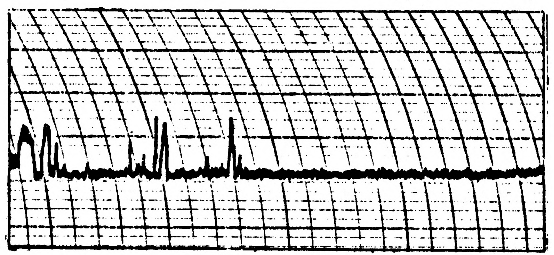


4h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



4i

Probable Cause

Equipment

The torque variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

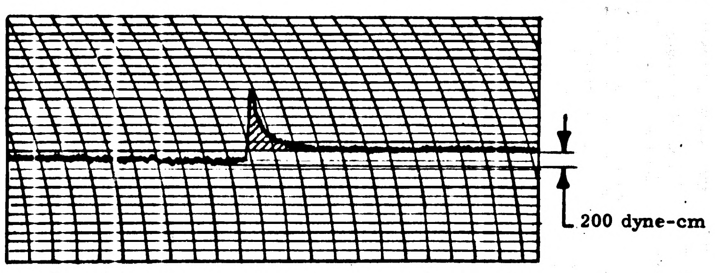


Fig. 5

Calculate cross hatched area of oil jog as called out in paragraph 2.1.2.3

APOLLO II IRIG Specification
MC 25-862 C
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

ASSEMBLY PROCEDURE FOR SUSPENSION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
3/18/65	B	17644	1, 2, 3	WK	WJR
4/2/66	C	36024	2	PK	

TP#11938

This MC specification consists of page 1
to ___ and 1 to 3 inclusive.

Rev A 10-30-64
RevB 3-18-65

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964
MC25-862
SHEET 1
OF 3

ASSEMBLY PROCEDURE FOR SUSPENSION, APOLLO II IRIG

1.0 Core Winding Preparation

A 1.1 Assemble winding arbor B-82382 (2 parts) with suspension core 2021686. Be sure to assemble winding fixture so that winding arbor extension can be used if needed.

2.0 Suspension Core Winding

2.1 Suspension can be hand wound or machine wound.

A 2.2 Winding direction, number of turns per pole, type, and size wire are given on 2021657.

2.3 Coil pair ends shall come out on Small Dia. side of suspension core.

2.4 Strip coil lead ends approximately 1/2" from end.

2.5 With an ohmmeter check each coil pair for grounding to core upon completion of winding. Identify Pole #1.

2.6 Determine pole-pair ends by continuity method and twist individual coil pair ends together to keep separated.

2.7 Measure coil-pair resistances with a Wheatstone Bridge. The four Resistance readings shall have a spread of 5% max.

3.0 Forming

A 3.1 Insert slot papers 2021584 in each slot. Use nonmetallic instrument for forming.

3.2 Trim slot papers to approximate length as shown.

3.3 Form coils by sliding forming fixtures over winding arbor until forming fixture ends are flush with winding arbor ends.

3.4 Most units do not require forming but it is a good idea to run through the steps anyway.

4.0 Lead out Wire Assembly

4.1 Slots where lead out wires are to be inserted require 2 slot papers. Follow same procedure as previously outlined.

4.2 Make lead out wire clearance hole between slot papers with a non-metallic instrument.

4.3 Strip lead out wires 1/8" back from end and tin (60-40 Solder Kester 1571 Flux). Push lead out wires up between slot papers until 1/2" is protruding above coil.

4.4 Strip and solder (60-40 Solder Kester Flux) coil end wires to appropriate lead out wires. Trim excess lead out wire for smooth joint.

TDRR 14531 NOV 25 1964 A71

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: D. Freeman, D. Zickefoose
DATE: February 25, 1964
TDRR 36024 APR 2 1968
MC 25-862 C
SHEET 2
OF 3

4.5 Pull lead out wires back so that solder connection is below surface of coils.

4.6 Remove Winding Arbor.

4.7 Wash unit ultrasonicially in Ethyl alcohol for approximately 1 minute to remove flux residue then wash ultrasonically in freon for approximately 10 minutes.

5.0 Preliminary electrical tests

A 5.1 Make polarity check per 2021657. Make insulation tests with 250V megohmmeter DC(500 megohms minimum).

6.0 Final Lead Out Wire Assembly

B 6.1 Apply LCA-9 to top and bottom of cell slot to secure the lead out wire.

BA 6.2 Apply thin coating of LCA-9 on common coil lead that runs across top of other coils.

6.3 Cure Assembly for 2 1/2 hours at 180°F.

7.0 Prepot Electrical Tests

7.1 Perform Shorted turn test.

7.1.1 Connect and excite per Fig 1.

7.1.2 Series tune each of four coil pairs, recording V in and C at resonance.

7.1.3 Measure the DC resistance of each leg.

7.1.4 The DC resistance spread, the Vin readings spread, and the Ct spread shall be 5% maximum.

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman, D. Zickefoose
DATE: February 25, 1964
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B

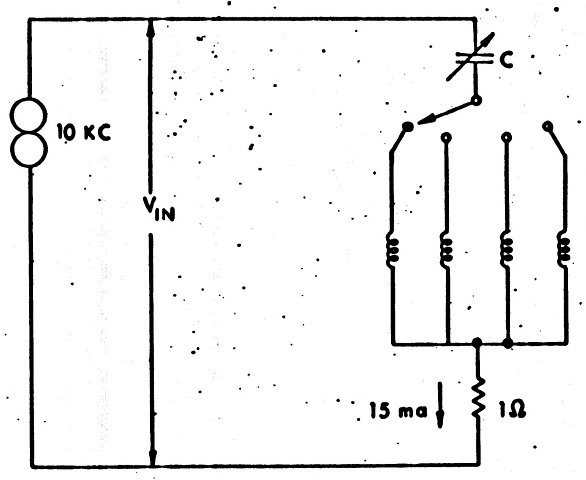


FIG. 1

APOLLO II IRIG Specification
MC 25-852
Release Date Jan. 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
5/7/65	B	18713	1, 3	WAK.	WJR
7/5/68	C	36502	All	PKL	See TDRR

TP#11938

This MC specification consists of page 1
to____and 1 to 6 inclusive.

TDRR 15323 JAN 6 1965

ASSEMBLY OF SHROUD TO GYRO UNIT, APOLLO II
SHROUD END COVER ASSEMBLY

Equipment and Materials Required

450 Watt Hot Plate
50 Watt Soldering Iron Pyramid Tip
Variac
Solder - Sn 96 Ws
Solder - Sn 60 Ws
Flux -Kester 891- Kester 1571
Artist Brush #3 - Acid brushes
Trichloroethylene
Freon
Ajax, Powdered Boraxo
305A and 38-1200 lapping Compound
#00 and medium grit polishing paper

1.0 End Cover Preparation

A. Rough up the areas to be tinned on all the shroud parts, using a medium grit polishing paper, steel wool or equivalent.

B. Clean all the parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, follow by an ultrasonic rinse in clean freon for the same time period.

C. Leak check the end covers for porosity using fixture 2A3-10B182.0 (Optional)

2.0 Tinning Procedure

A. Place the end cover on hot plate and heat to 250°F ± 10°.

B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.

C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.

D. Repeat steps B and C on inside of cover.

E. Remove from hot plate and allow to cool.

3.0 Cleaning Procedure

A. With an acid brush scrub the end cover using clean trichloroethylene.

B. Follow by scrubbing under running hot water using Ajax powered Boraxo or equivalent.

C. Thoroughly rinse under running hot water and dry.

4.0 Assembly of Seals to End Covers

A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux.

B. Refer to 1.0 para. "B" for cleaning procedure.

C. Tin the .125 diameter on the 16 terminal seals, 2021508, with Sn-96 solder and 1571 Kester flux. Clean as in step 1.0 para "B".

D. Apply 1571 flux to tinned area.

E. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position.

F. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.

G. Carefully remove from the hot plate and allow to cool.

H. Repeat cleaning procedure #3.

I. Polish the end covers using 305A lapping compound, followed by 38-1200 compound. Final clean as in step #3.

J. Seal the degassing plug hole with the aluminum ball and seal screw. Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.

K. Hi Pot - 250 volts (DC).

L. Tin the 2.443 diameter on the end cover with SN-60 solder and Kester 891 flux. Clean as in step 3.0.

M. Meggar check the assembly 250 volts DC.

5.0 Main Cover Preparation

A. Tin the 2.440 diameter and two .010 deep relief with 60 40 Solder and Kester 891 flux.

B. Refer to step #3 for cleaning.

6.0 Insert Preparation

A. Tin concave side with 60-40 solder and 891 Kester flux.

B. Refer to step #3 for cleaning.

7.0 Internal Connector Assembly

A. Check the connector assembly for shorts or opens.

B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.

C. Carefully clean all joints with trichloroethylene and artist brush, followed by a freon rinse.

D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.

E. Leak check assembly as in of step #4.

F. Apply LCA-9 adhesive (MC 25-302)over the glass seals and any exposed wires. Cure for two (2) hours minimum at 200°F ±5°.

G. Form the wires carefully at terminal to provide a 180° bend strain relief.

H. With lacing cord or shrink sleeving secure each pair of 8 wires in two places about one inch apart.

I. Make a final electrical check on assembly.

J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)

8.0 Assembly of the Shroud To Gyro Unit

A. Measure and record the bellows extension_______in.at 135°F±5°.

APOLLO II IRIG Specification
MC 25 -882
Release Date ______
Release Revision —
Class A Release
TDRR 35599

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	RT Smith	
6/21/68	A	36392	3, 11	PRK	--
8/1/68	B	36605	2	PRK	--
11/20/68	C	37036	2	PRK	--

This MC specification consists of page i
to ___ and 1 to 11 inclusive.

TP# 11938

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm
n = Number of run-down time checks (no less than 8)
$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.

To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic or step power variations that are greater than 20 milliwatts. The maximum variation in mean power level shall not exceed 50 mw. Figs. 1a, b, c represent acceptable power traces. 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.

The maximum allowable trace width during the monitoring period for an acceptable wheel is 40 mw. The maximum allowable variations in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11-15	20
15-20	25
20-25	30
25-30	35
30-35	40
35-40	40

2.2.2 Provisionally Acceptable Power Trace

There are two categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

[illegible]

2.2.2.1 Test Equipment Influences

Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.2 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig. 3i).

B. Allow the gyro to cool down and remain at room temperature during the shrouding operation.

C. Carefully inspect the O.D. of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

D. Align the open ports in the main cover with the +SRA and +IA gyro axis.

E. Install the end cover assembly on the unit, carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

F. Perform an electrical check for correct resistances, opens and grounds.

G. Apply a minimum amount of 1571 Kester flux to main cover- end cover joint with a piece of solder or a small artist brush.

H. With a 50 watt soldering iron (Pyramid Tip) make the joint between the main cover and end cover.

I. Excess solder can be removed with a sharp edge dental tool, and hard rubber abrasive eraser.

J. Repeat steps "E" through I for remaining end cover.

K. Clean the joints by brushing with an acid brush and clean trichloroethylene, followed by a brushing with clean freon.

L. Perform complete electrical check of unit.

9.0 Leak Check of Shrouded Unit

A. Carefully assemble the unit to the leak check fixture, C-127683.

B. Seal off the exposed end with the aluminum ball (17S-T4) and #2-56 x 3/32" long sealing screw. Leak check this end of the unit. Maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

C. Remove seal screw and aluminum ball.

D. Repeat steps "A" through "C" for the opposite end of unit.

10.0 Decals

A. Clean the ends of the shroud covers with a Kimwipe dampened with trichloroethylene. Remove the protective backing from the T. G. decal and fasten the decal to the T. G. shroud end cover. Aligning the IA arrow such that it is pointing toward the degassing seal. Smooth out the decal using finger pressure to eliminate ridges, air pockets, etc. Repeat the operation for the S. G. decal aligning the lettering such that it reads in a direction which is perpendicular to the degassing seal.

11.0 Preliminary Testing

A. Refer to MC 25-905 for preliminary testing procedure.

12.0 Final Shroud Sealing After Preliminary Testing

A. Cool gyro to room temperature.

B. Apply a minimum of Kester 1571 to the two (2) 0.010 inch deep reliefs on the sleeve and concave surface of the inserts.

C. Position the inserts on the sleeve so as to follow the general contour of the 2.460 diameter.

D. With a 50 watt soldering iron and Sn-60 solder, make the joint between the sleeve and inserts. Remove excess solder as before. Clean the joints with an acid brush and trichloroethylene, followed by a brushing with clean freon.

13.0 Final Leak Check of Shrouded Unit

A. With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S. S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683. Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the

terminals, ports and main seam at the end with helium. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

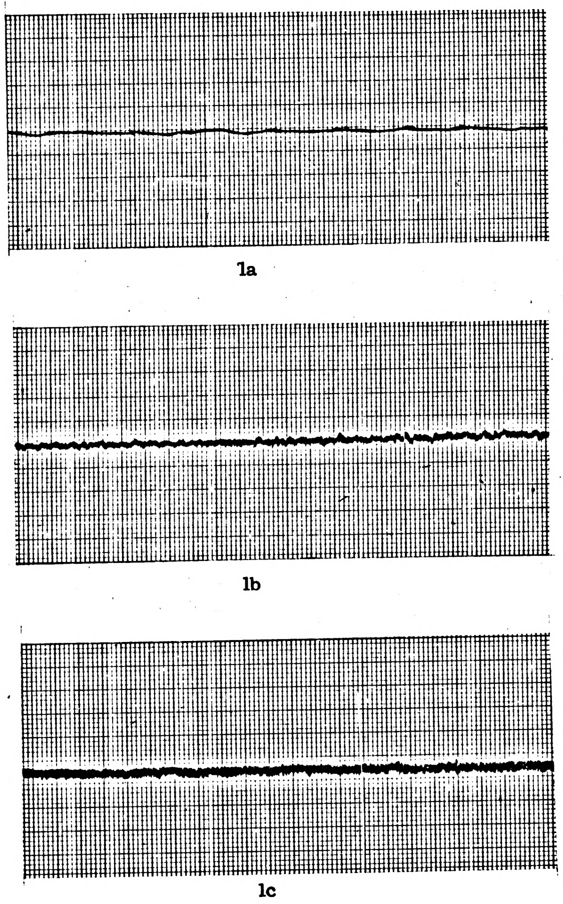
B. Remove the sealing screw and aluminum ball from the unit.

C. Invert the unit and leak check as before.

D. With the unit still on the leak check fixture and 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug. Remove the unit from the fixture and retorque both set screws to 28-30 in. oz.

E. Final test per MC 25-905.

F. Store in a 135° ±5°F. oven awaiting delivery.


1a

1b

1c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sce ± 15%

Fig. 1 Acceptable Power Traces

Fig. 2a Deleted

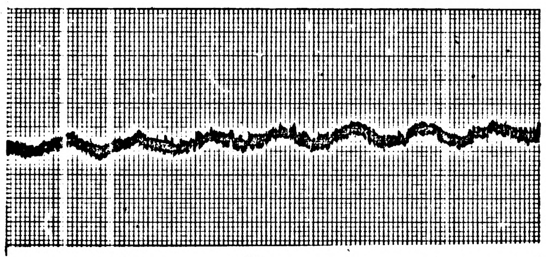
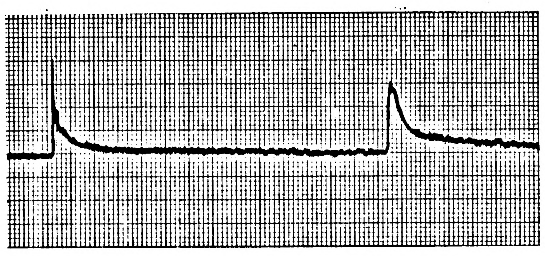

2b

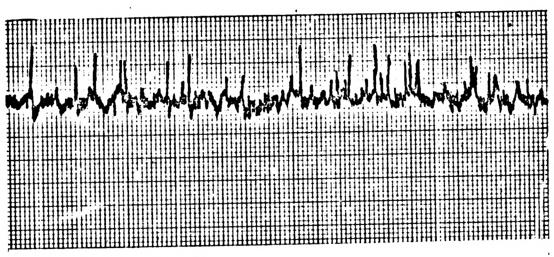
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

Fig. 2c Provisionally accepted power trace due to oil jog.

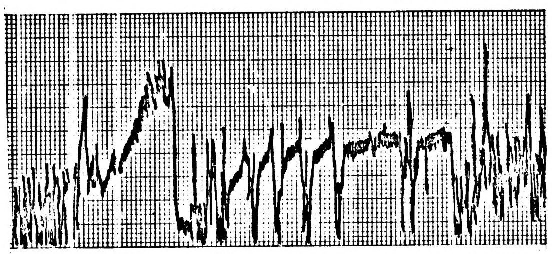

3a

Probable Cause

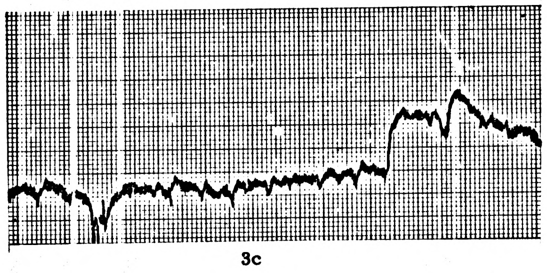
Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer super-imposed on a rough and irregular power trace.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

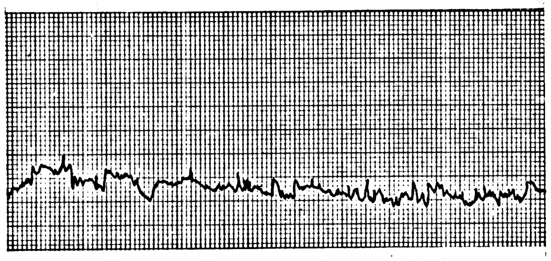
Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.


3c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces

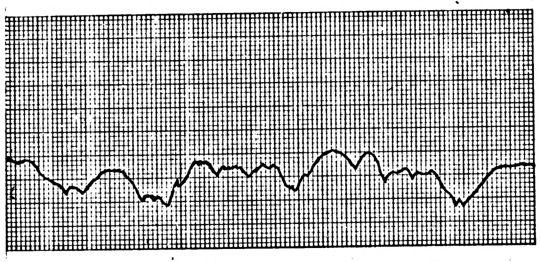


3d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced power variation.



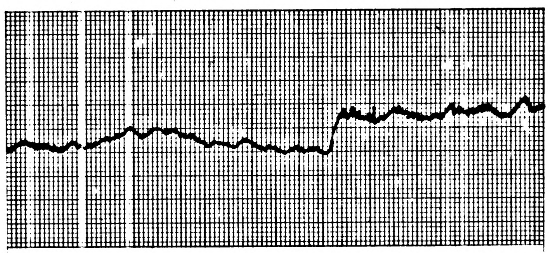
3e

Probable Cause
Varnish
Debris

A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

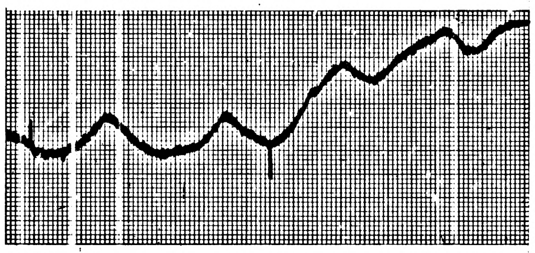


3f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



3g

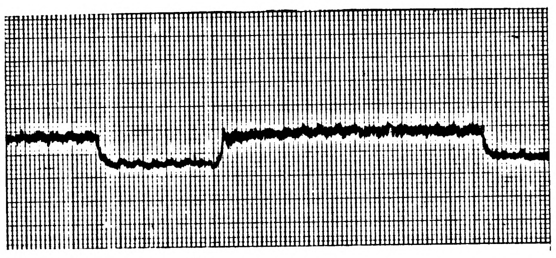
Probable Cause

Varnish

This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

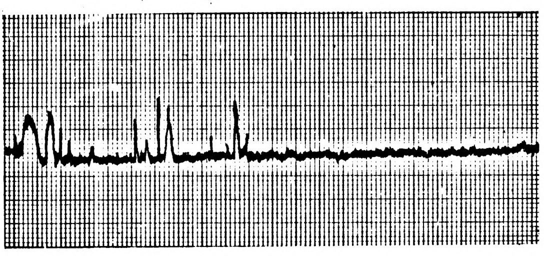


3h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light ot control the angular velocity of the ball group in one bearing.



3i

Probable Cause

Squeal

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

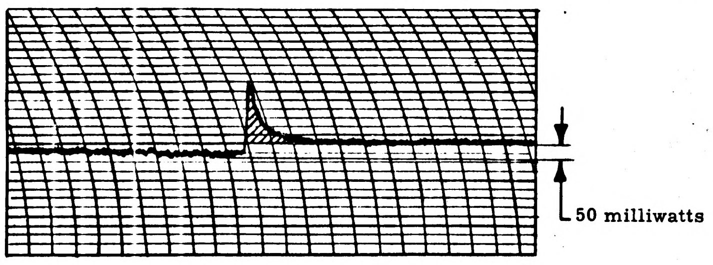


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.3.

APOLLO II IRIG Specification
[redacted] MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
12-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13		
9-20-65	C	22893	5, 6, 7, 9, 10, 11, 12		

This specification consists of pages i
to ____ and 1 to 13 inclusive.

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CAMBRIDGE, MASS.
PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964

MC 25-853

Rev B 12/21/64
Rev A Revised and Rewritten 10-24-64

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

1. Sub-Assemblies and Parts to be Demagnetized
   - A. All magnetic parts prior to final assembly.
   - B. Float Assembly, Dwg. 2021619.
   - C. End housing assemblies, Dwg. 2021663 and 2021649.
2. Float Preparation
   - A. Cementing the rotors to the stub shaft.
     1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
     2) Assemble the rotors to the float to insure proper seating.
     3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
     4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
     5) TG rotor should be aligned per MC 25-618 step A, 11.
     6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
     7) Place assembly in oven and cure for 1-1/2 hours minimum at 150° ± 5°F.
     8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

TG End ______________ TIR
SG End ______________ TIR

Maximum allowable runout on either end 0.0005 TIR.

3. Float Measurements
   - A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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MC 25-853

4. Flotation
   - A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

Weigh the float and record ____________gm.

   - B. Determine the neutral buoyancy, end for end and rotational balance as follows:
     1) Place the float in an oven at 140°F for about 15 minutes.
     2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
     3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
     4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

B Weight in air of solder on holder at TG end ______________.
B Weight in air of solder on holder at SG end ______________.

Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

Weight (in air) added to TG end ______________
Material ______________
Weight (in air) added to SG end ______________
Material ______________
Total float weight in air ______________

     5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

   - C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

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MC 25-853

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

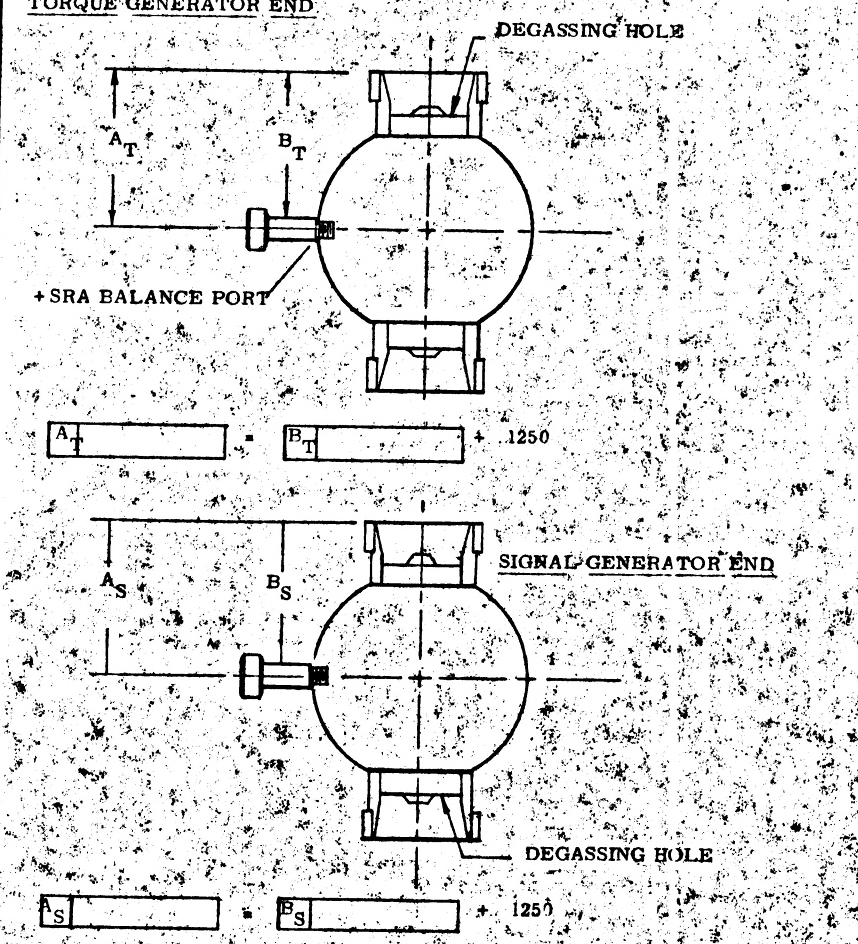
NOTE: Plummets may be used to check fluid density while performing flotation.

   - D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.
   - E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.
   - F. Leak check and record ______________ atm-cc/sec.

Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

FLOAT MEASUREMENTS

TORQUE GENERATOR END



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5. Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.

B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly

A. End Cap Assembly

1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.

2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.

3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.

4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

B. Thermistor Installation

1) Procure thermistor per 2021518.

2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)

3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation

A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:

A. K&D #100 round nose for spreading.
B. K&D #106 flat for staking eyelet to counterbore.
C. K&D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.

F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.

E. Repeat A through D for the second damping block.

10. Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing

A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_s in the support block A-118435.

Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

B. Carefully lower the float into the main housing, with the torque generator up, the B- facing the assembler and + SRA to the left.

C. Insert the dummy stop pin A-92284 into the + SRA balance port, and secure it with a locking screw.

D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer.

12. Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.

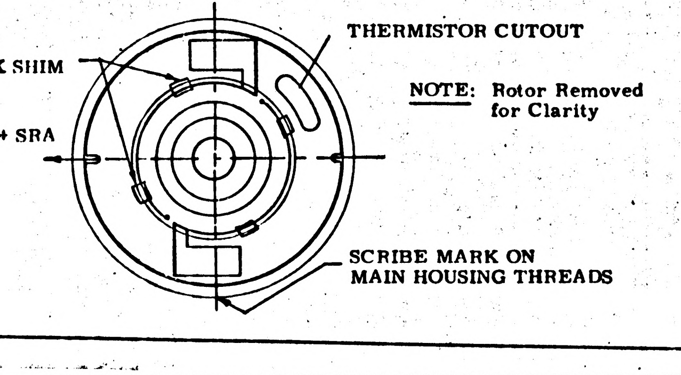
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

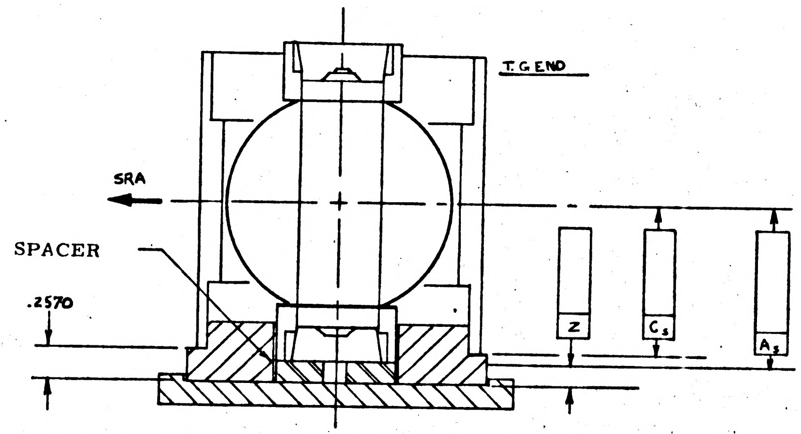
D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.

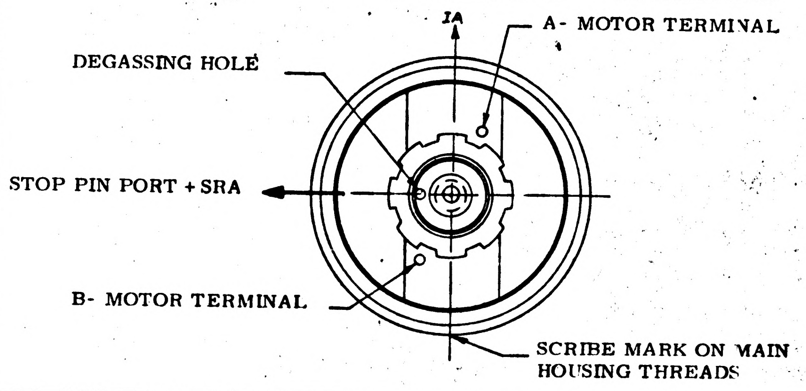

THERMISTOR CUTOUT
.044 THICK SHIM
+ SRA
NOTE: Rotor Removed for Clarity
SCRIBE MARK ON MAIN HOUSING THREADS



Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

Z_s = 0.2570 + $\boxed{C_3 \qquad}$ - $\boxed{A_s \qquad}$

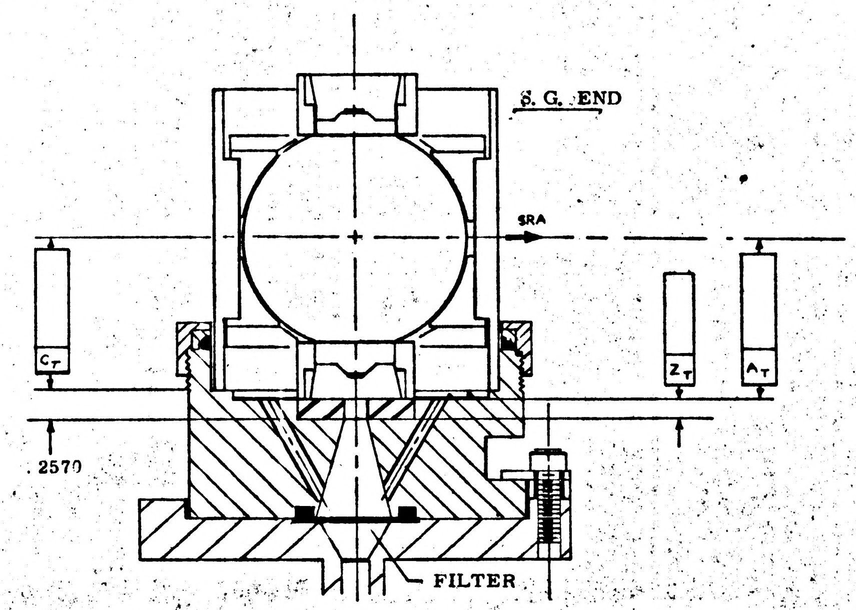


C 13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



Z_T = 0.2570 + $\boxed{C_T \qquad}$ - $\boxed{A_T \qquad}$

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O. D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O. D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

B H. Solder the flex leads to the spring tab and float terminals as before.

C 14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3; invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 50 microinches.

E. Apply Damping Fluid (MC 25-612) sparingly to the pivot body and then wipe thoroughly with lens tissue. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

C 16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut.

C 17. Dry Centering

A. Dry center the instrument as per MC 25-854.

C 18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 60 in-lbs. Invert unit and repeat above procedures.

C 19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1 x 10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page # 13.

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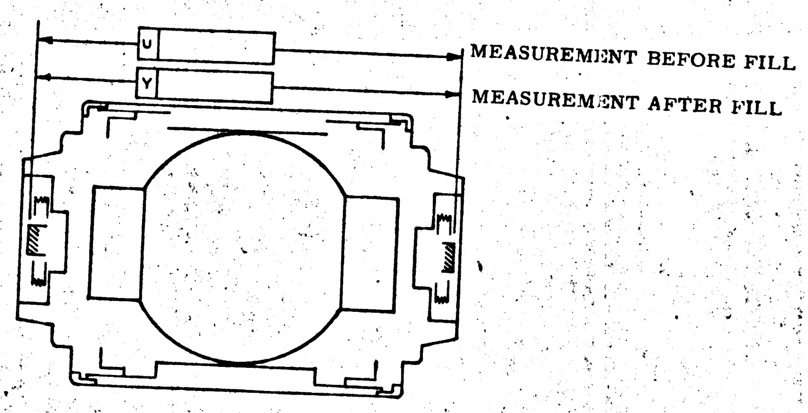
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964
MC 25-853
SHEET 12
OF 13

CB

20. Bellows Measurement

A. Measure bellows overall length and record below.
B. Weigh the unit and record.
C. Fill the instrument as per MC 25-816.
D. Calibrate the thermistors per MC 25-800.



Weight of Unit Before Fill -------- ☐ Grams

Weight of Unit After Fill -------- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding -------- ☐

Min. bellows extension before shrouding = 0.130" Total

Weight of Unit After Shrouding ------- ☐ Grams

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CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64
MC# 25-853
SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_Y					
S_H TO S_L						T- TO T_Y					
S_L TO SSQ1 SEC						T_Y TO T_Q					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					
MOTOR CIRCUIT											
A- TO A+											
B- TO B+											
A- TO B-											
A+ TO B+											

APOLLO II IRIG Specification
MC 25-884 REV C
Release Date ________
Release Revision __-__
Class __A__ Release
TDRR __35599__

NYLASINT RETAINER PROCESSING SPECIFICATION

	Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
ⓜ	13 FEB 68	—	35599	INITIAL RELEASE	R Booth	
ⓜ	3-22-68	A	35932	1, 2, 3		--
ⓜ	8/1/68	B	36622	1-3		--
	12/10/68	C	37111	3	MGM EA	WLS

TP#11938

This MC specification consists of page i to____and 1 to 4 inclusive.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 35932 MAR 2 1968

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev B
SHEET 1 OF 4

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (Material per Dwg C-2021819) with V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per (Dwg C-2021816. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in. hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 20X magnification. Repeat steps a, b, or c, if necessary.

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CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev B
SHEET 2 OF 4

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150° -160°F and 29 1/2 in. hg. minimum.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0 ± .5 grams/minute at a line pressure of 80 psi minimum. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time(Tolerance: ±5 sec)
Ball Pockets	2 min. each pocket
Outer Diameter	2 min. total
Edges	2 min. each edge
Inner Diameter	20 sec. total

NOTE: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period)

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° ± 150°F and 25-50 microns.

f. Equipment
S. S. White Industrial Abrasive unit
model G
201 East 42nd Street
New York, N. Y. 10017 or equivalent
NOTE: Handpiece 351-1793y (approx .040 dia) without nozzle attachment shall be used as a nozzle

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

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PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev C
SHEET 3 OF 4

c. Finally inspect retainer for absence of burrs, contamination, and damage under 20X magnification.

d. Holes from pull out of solid nylon inclusions will be permitted on the I.D. surfaces and side edges of the retainer. Pull out at the edges of the ball pocket surfaces which intersect the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. and O.D. surface and the ball pocket surface. The depth of blend may not exceed 0.010 inches into the ball pocket or the O.D. or I.D. surface. (See fig.1).

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material. No inclusions will be permitted where ball makes contact in pocket. NOTE: Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown and black) inclusions are acceptable only if they are imbedded below the surface of the retainer surface.

8. Oil Absorption Test

a. Check retainers for oil absorption test per MC 25-911.

b. After oil absorption test reclean the retainers per paragraphs 6c, 6d, and 6e of this specification.

9. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage enviroment.

c. The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.

MC 25 [illegible]

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CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884
SHEET 4
OF 4

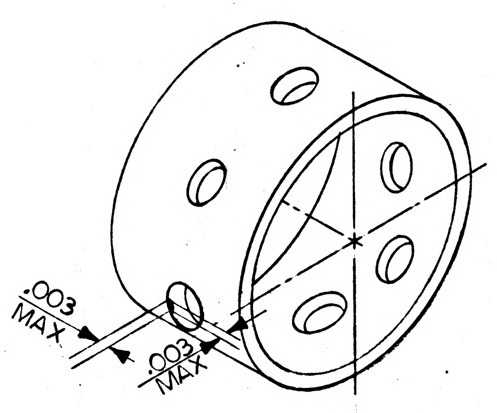
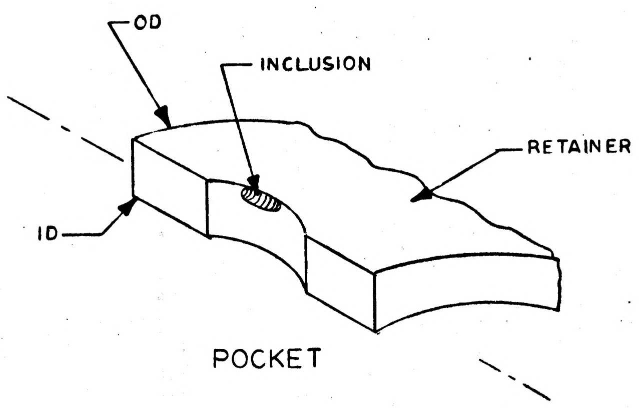

.003 MAX
.003 MAX

FIG 1
BALL POCKET BLEND


OD
INCLUSION
RETAINER
ID

POCKET

APOLLO II IRIG Specification
MC 25-855
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4-30-65	B	18829.	1, 4, 5	WK.	
10/6/67	C	35603	4, 5.	DRK	

TP# 11938

This MC specification consists of page i ~~to~~ ___ and 1 to 7 inclusive.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 1 OF 7

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.

1A. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA________________-SRA________________

Record I. D of hemisphere shaft bore

+SRA________________-SRA________________

Average Interference

+SRA________________-SRA________________

2. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

A 3. Clean all the float parts in trichloroethylene followed by a freon rinse.

4. Weigh all the float parts and record information on sheet #6.

5. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Clean the parts as in step #3.

Rev A 10-26-64
Rev B 4-30-65

6. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

7. Measure and record the following:

A) O. D. of stator________________

B) I. D. of gimbal________________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".

C) Average interference________________(.0001-.0003)

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 2 OF 7

8. Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.

B. Place the bushing A-92287 into the pressure plate.

C. Assemble the motor stator to the pressure plate A-87423.

D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O. D.

F. Remove the gimbal and fixture base from the hot plate.

G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.

A H. Remove fixture and check centering of the stator in the gimbal. Check continuity.

A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

9. Weigh gimbal and record________________gms.

A 10. Grind I. D. of motor stator as per drawing 2021625.

11. After grinding, perform visual inspection, and clean this assembly in varsol followed by a freon rinse. Check continuity.

12. Weigh gimbal and record________________gms.

A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

13. Power Lead Installation

A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F oven for 1/2 hour.

B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 3 OF 7

C. Repeat step "B" on oppostie end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F.

E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F.

14. Install .062 diamter ball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10 x 10^{-8} ATM cc/sec. Leak rate________________

A 15. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt. cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10 x 10^{-8} ATM cc/sec.

Leak rate________________

16. Remove the sealing screw and .062 diameter ball from the degassing hole.

17. Assembly of wheel to float

A. Thoroughly clean all float parts in filtered freon.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on thermostatically controlled hot plate set to 350°F + 15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from sealed plastic bag. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms.

A NOTE: Nylon gloves or finger cots to be worn when handling wheel.

18. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

19. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

20. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.

21. Heat the -SRA hemisphere as in "B" of step #17.

22. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

Rev. C 10-6-67

23. Carefully assemble the wheel and +SRA hemisphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

24. Balancing the float in Air

A A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

25. The float at this time is complete except for the rotors and balance weights. Weigh the float and record ______________ gms.

26. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T. I. R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 2.

B 28. Refer to MC 25-803 or MC 25-869 or MC 25-880 for instructions on setting the +SRA bushing.

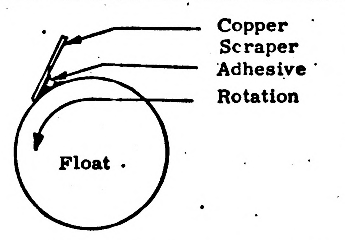
27. Solder (4) 18" long lengths of #30 wire to the power leads using 60-40 Kester solder and 1571 flux.

B 29. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 180°F oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.

Rev. B 4-30-65 (Revised & Retyped)
Rev. C 10-6-67



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 180°F max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 180°F.

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms.

B. Place a 2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

The following alternate procedure may be used:

Install float in fixture as described above. Draw a vacuum of 15" Hg and then admit helium to 0" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as above.

C. Weigh the float and record ______________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. ____________gms.

31. Leak check and record ________________atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min.

33. Leak check and record ________________

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 34. Refer to MC 25-803 or MC 25-869 or MC 25-880 for float run-in requirements.

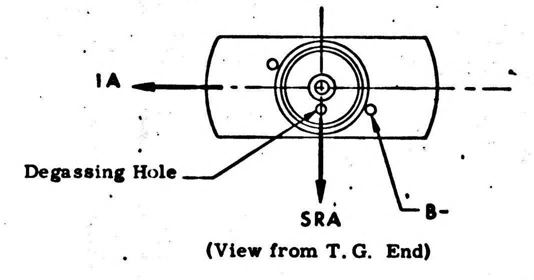
FLOAT WEIGHT RECORD

Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
A-87287	4	Power Lead-in		.092	
A-107251	8	Balance Weight (Final Rot. Adj.)		.740	
A-107252	4	Balance Weight Spring		.018	
A-87391	2	Centering Shim		.013	
B-87374 *	2	Bushing		1.676	
Comm'l.	1	#2-56 Sealing Screw		.037	
Comm'l.	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
C-87373	2	Hemisphere		14.701	
D-112977	1	Gimbal		26.051	
B-87289	1	Motor Stator (Finish Ground)		18.800	
C-118575	2	Rotor Assy.*		32.968	
C-87341	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	18.702		
	As Req.	Adhesive for Sealing		.100	
A-84046	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

A

*Rotors installed at final assembly.



(View from T. G. End)

Fig. 1

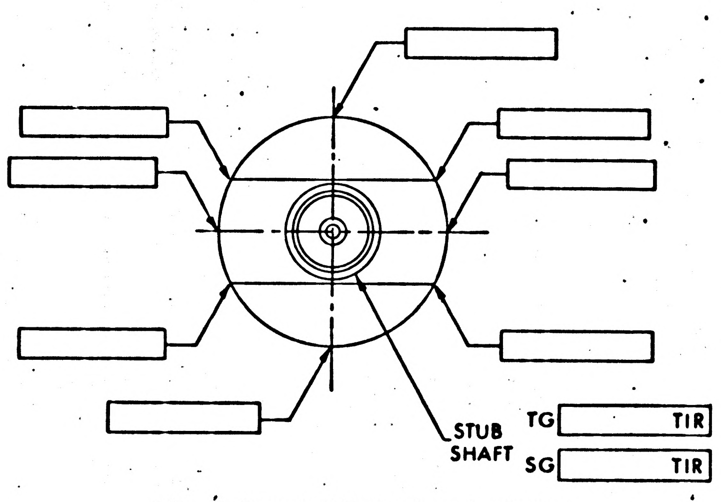


Fig. 2 Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC 25-856
Release Date Nov. 25 1964
Release Revision A
Class 1 Release
TDRR 14531

TITLE: Main Housing Assembly Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
3/19/68	B	36403	1	PRL	
12/5/68	C	37101	1	MGM EA	WLS

TP#11938

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: 19 March, 1968
MC 25-856 Rev C
SHEET 1 OF 2

MAIN HOUSING ASSEMBLY PROCEDURE

1.0 Lap the two (2) clamping caps, and the four (4)#00-96 screws, also the 0.218" diameter of the two main housing ports with fixture, 2A3-10B153, using 305A lapping compound. Refer to MC 400 for handling of beryllium.

2.0 Match the end housings by selecting end housing assemblies whose suspension currents are equal within 6.0 ma as measured per MC 25-859 and MC 25-860.

3.0 Clean all the parts ultrasonically in trichloroethylene for five minutes minimum, followed by an ultrasonic rinse in clean freon for the same time period.

4.0 Lapping the End Housing to the Main Housing

A. Assemble the end housing to fixtures 2A3-10B163. Lap the mating taper of the end housing to the main housing using #305A lapping compound until there is a gap of 0.0005" to 0.001" between the end housing shoulder and the main housing face.

B. Clean the end housings and main housing by scrubbing while immersed in warm varsol 90°F ± 5°, followed by a thorough rinsing in clean freon.

C. Lightly blue the end housings and check its fit to the main housing. There should be 70% circumferential contact minimum.

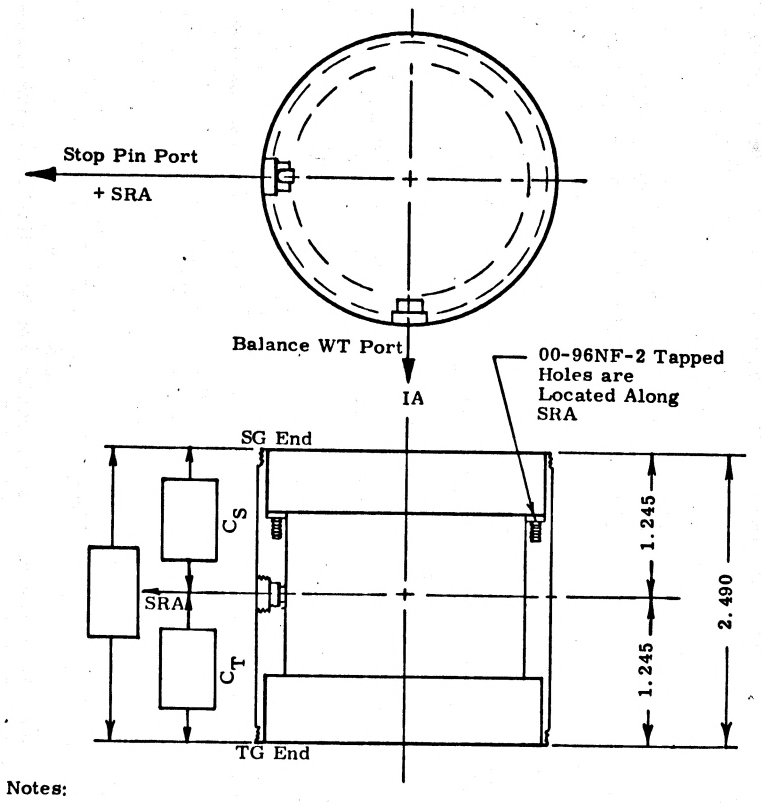
D. Clean off the bluing with a Kimwipe dampened in acetone, followed by cleaning as in step "B". Scribe the ends of the main housing and the mating end housing with # 1 and # 2 for later identification.

5.0 Measure and record the dimensions indicated on next page.

6.0 Store the main housing and selected parts in a clean container until required.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: March 19, 1968
MC 25-856
SHEET 2 OF 2



Notes:

1. Measure the dimensions shown (the location of the SRA Balance Port). Record in the blocks provided.
2. All readings to be to 4 decimal places.

APOLLO II IRIG Specification
MC 25-880 REV D
Release Date 8 FEB 68
Release Revision ——
Class A Release
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	~~NASA~~
8 FEB 68	—	35585	INITIAL RELEASE	R Booth 2-7-68	——
8/1/68	A	36624	All, except 8, 20, 24.	B Rockower 9-17	——
1/21/69	B	37228	20	MGM EA	WLS
1/31/69	C	37287	10	MGM EA	WLS
2/21/69	D	37379	19, 20	EA	RJJ

TP#11938

This MC specification consists of page i
to ___ and 1 to 24 inclusive.

MC 25-880 REV A

APOLLO II WHEEL PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo II wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer (C-2021816) shall be packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per (MC 25-878). Check and inspect the bearing surfaces. No defects will be accepted on balls and critical areas of inner and outer races as defined by fig. 1 (MC 25-887) (e.g., corrosion, brinelling, burrs, stains, gage marks, raised metal, tears, cuts, scratches, stringers, nicks, dents, digs, gouges, comets, pits, and inclusions). Check for oil wettability per (MC 25-890).

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurements. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurements are made and record this information together with the average O.D. measurement on (MC 25-886). Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para 7.

1.5 Reclean the outer race per (MC 25-878) as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. The oil shall be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
Quick Seal type 150 Natl. Inst. Co., Baltimore, Maryland
Master Gage Plugs, Class XXX (.180000-.180020)
Sheffield Air Ring with two small jets for measuring the (.180000-.180030) diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring (.3748-.3749) diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749, .3750, .3751)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2.0 INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC 25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture (B-87392).

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F, immerse wheel hub into liquid nitrogen until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps 2.6 through 2.8.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve (A-87392.5) and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press
Simpson Model 388 thermocouple indicator or equivalent.

3.0 TEMPERATURE CYCLING

3.1 Place in a suitable closed glass container. [illegible] foil.

3.2 Place in the cycling container, (2A3-10B177) Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and +200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber
Reynolds Aluminum Foil

4.0 LAPPING BEARING BORES

NOTE: Insure that all finished 0-80 tapped holes of hub element have been lapped. [illegible]

4.1 Measure the lapping room temperature and, using the wheel assembly data

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MC 25-860
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

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Procedure for Testing
TG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/2/65	B	16570	1 & 3	WK.	
3/18/65	C	17646	1, 3	WK.	WJR
6/8/65	D	20018	1	WK	

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PROCEDURE FOR TESTING TG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

- A 1.1 Mount rotor and stator on an air bearing torque test fixture device DRC-67-M-3 or equivalent.
- 1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5% F during testing.
- A 1.3 Rotor ID run-out torque-summing member shall be 0.00005" TIR max.
- A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

- 2.1 Connect and excite the assembly per Fig. 1.
- 2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.
- 2.3 Center microsyn angularly by rotating for minimum E_o.
- DB 2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1°. and I_m = 43.5 ± 3 ma.
- A B 2.5 Disable T_{comm}. Measure and record suspension reaction torque. (0 ± 0.15 dyne-cm)

3.0 Torque Generator

- 3.1 Reconnect per Fig. 2 and adjust for null.
- 3.2 Connect and excite per Fig. 3A and measure current-squared squared torque sensitivity.
- 3.3 Repeat per 3B. If + and — torque sensitivities are not equal, dummy direct torque summing member to a new angle. Check + and — sensitivities until they are equal within 1%. Record sensitivities. During this test, check radial centering, but disable suspension while torque measurements are being made.
- 3.4 Reconnect per Fig. 2.
- 3.5 Measure and record magnitude and relative phase of E_o at the angle found in 3.3. This information will be used in Dry Centering Procedure MC 25-854.

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- 3.6 Place an indexing mark on the + or — IA axis of the rotor. This information is used in Final Assembly Procedure MC 25-853, step 2.A.5.

A 4.0 Bias Winding

- 4.1 Disable suspension and TG, zero all airbearing torque.
- 4.2 Measure and record the torque sensitivity of the bias winding. Connect reset coil and bias winding in series. Excite with 20 and 40 ma at 3200 cps. Average and record the torque sensitivity. Do not exceed 100 ma.

5.0 Residual Torque Test

- 5.1 Use residual torque testing electronics dwg #D128144.
- 5.2 Disable suspension and TG. Zero out all air bearing torques.
- 5.3 Apply 3 pulses to T+ winding. Read torque.
- 5.4 Apply 3 pulses to T- winding. Read torque. Calculate the difference in torque readings. Record.
- 5.5 Apply 50 ma at 3200 cps to the reset winding and repeat 5.3 and 5.4. Record Δ torque.

CB

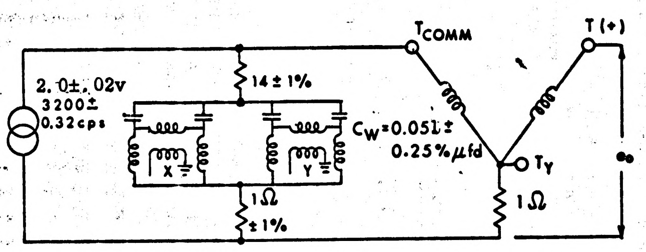

Fig. 1

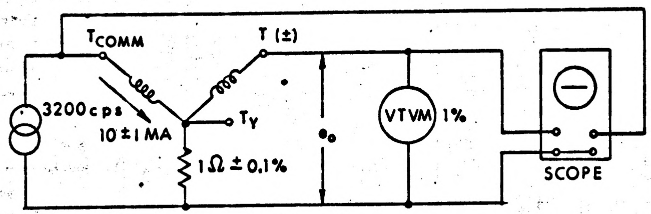

Fig. 2

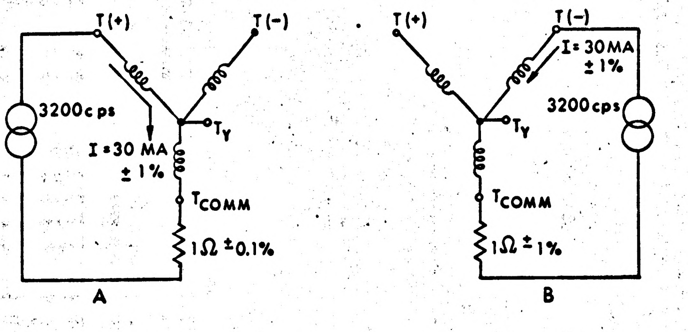

Fig. 3

sheet (MC 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffiel Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lappin compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator or Cleveland Indiron should not exceed 20 microinches, and should not extend more than .050" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (MC 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150° ± 5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
Model 153-40 used with small jet spindles and Class XXX Master Gage Rings
Hand Lap-3/8" dia. x 3" long-American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Co., Inc.
Zeiss Stereo Microscope or American Optical
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner
Cleveland Indiron

5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries inc.,
Sycamore, Illinois

6.0 'B' DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.976000 gage block and the Johansson Mikrokator S 510- E-8, measure accurately (to within 5 microinches) dimension 'B' and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment

C.E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per (MC 25-878).

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used. Insure that interference is reduced to a minimum by predenting the ball pockets. This should eliminate possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

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measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture (D-95850). Rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\cos\beta = \frac{E}{d}\left[1 - 2\,\frac{N_e}{N_i}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on (MC 25-886.)

Equipment
Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension "A" as recorded on bearing package by manufacturer, and dimension "B" as measured in section 6, determine spacer thickness by using the following formula:

$A = B + t - 65$ microinches
or $t = A - B + 65$ microinches

where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 20 microns minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE

9.2.1 Centrifuge retainer for 15 ±1 minutes at 9000 ± 150 G's one side only.
9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.
9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 20 microns minimum.
9.2.4 Remove retainers from oven and weigh immediately.
9.2.5 Compute oil retention of each retainer as follows:

$$\%\ \text{retention} = \frac{W_1 - W_o}{W_0} \times 100$$

where W_0 = weight of dry retainer

W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.
If oil retention is outside specified retention range, retainers may be re-soaked in oil and/or recentrifuged varying the times to achieve the specified retention limits.

9.2.6 After retainers are impregnated, O.D. of retainer, pocket diameter and, pocket alignment shall meet tolerances shown on (Dwg. C-2021817).

9.2.7 Store retainers in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

9.2.8 General Notes:

X 9.2.8.1 Retainers should be handled with bone tweezers or gloves to minimize moisture absorption and contamination.

9.2.8.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.7 above.

9.2.8.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ± 5°F and 20 microns minimum, outgas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ± 5°F and 20 microns minimum for 18 hours minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6 above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies (2A3-10A187-1) or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ± 5°F allowing 15-20 minutes for temperature to stabilize.

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10.3.1.2 Remove from oven and install assemblies into centrifuge plate (2A3-10C187-1), or equivalent, and spin for 10 minutes ± 1/2 minute at 4000 ± 100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Remove from centrifuge and blot retainer edges with lens paper. Place retainers in oven at 150° ± 5°F for 3 to 6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percentage (%) absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 After recording weight and percentage retention, place in pyrex dish using desiccants to minimize the humidity of the storage environment

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

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11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet can be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per (MC 25-878.)

11.3 Clean wheel inertial element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ±5°F and evacuate for one hour minimum at 29.5"Hg vacuum maximum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Prior to assembly, the balls may be prelubricated as follows:

Mix 500 parts of Freon to 1 part of oil in a beaker and immerse the balls. Vacuum dry the balls and examine them under a 25X - 30X microscope making sure that the balls are clean.

Assemble retainers, balls and outer races as follows;

12.1 With fixture (A-118577) assembled, place outer race with stamped end up on shoulder of fixture (A-118579).

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture (A-118578).

12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer. Inspect carefully with 25x to 30x microscope for contaminants.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy (A-118577)

12.5.1.1 Fixture (A-118579)

12.5.1.2 Fixture (A-118578)

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture (A-88948.3) with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with stainless steel tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer (C-221670) over the bearing and use fixtures (A-88948.) and (A-88948.2) to press into the bore. The force necessary to push the bearing into the bore will be in the range of 2-5 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above, press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight. NOTE: Insure that all threads of 0-80 have been lapped prior to assembly.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Place corresponding end of shaft upward on shaft holding fixture ass'y (Dwg. 166042). Hold element with installed bearing and install on shaft. Using wheel holding fixture (Dwg. 166045) install on top of element. Invert entire fixture ass'y so that wheel holding fixture (Dwg. 166045) becomes the base and carefully remove shaft holding fixture (Dwg. 166042).

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture (A-88948.1) and (A-88948.2) to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements).

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen head screws .187 long. NOTE; Insure that all threads of 0-80 Allen head screws have been lapped to remove burrs and smooth down rough edges. Assemble protective cap (Dwg. 166037) before using Allen wrench to adjust 0-80 screws.

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Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without placing any preload on the bearings.

13.13 Inspect with microscope at 30X heads only of 0-80 screws for loose particles of metal.

13.14 Remove dust protector if necessary prior to shaft strain.

14. SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter (A-92246.1) to the #2 end with the flat end inward and tighten to a torque of 0.75 in.lb (strain gage measurements at MIT indicate that 0.75 in.lb of torque produces 76 microinches/inch shaft strain and a corresponding 65 microinches shaft deformation). The 65 microinches shaft deformation will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION (Preload Fixture D-92272)

15.1 Assemble shaft adapter (A-92278) to the #2 end of wheel.

15.2 Assemble shaft cap (A-92277) to the #1 end of wheel. In assembly of these adapters care should be taken so that the applied torque does not exceed 0.75 in.lb.

15.3 Preheat wheel in oven at 150° ± 5° for 15 to 20 minutes. Remove wheel from oven and hand rotate shaft in one direction a sufficient number of times to prelubricate raceways and balls. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an additional 25-30 minutes and repeat prelubrication procedure. Once prelubrication is achieved, inspect bearings for contamination and repeat step 13.13

15.4 Allow wheel to return to room temperature and position wheel on top plate (C-94190). Assemble weight pan (A-92281) with a 1 lb. weight.

15.5 Carefully inspect clamping ring (C-94185) on top of wheel insuring that delrin washer (A-94186) contacts wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan (A-92281) to chain hanging from shaft adapter (A-92278).

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying a three pound load. Lift the weight, zero the meter, and then gently apply the three pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

Note: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap (A-92277). Maximum axial runout of shaft cap is 10 microinches with ±45° rotation.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft ±45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ±10 microinches the proper preload has been achieved. Unload bearings and repeat steps 15.8 thru 15.11 to ensure return to reference within the ±10 microinches. If repeatability is not achieved change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and record the displacement of the indicator from zero for each weight in (MC-811). These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on (MC-811).

15.14 Before preliminary dynamic balancing, position of cap, (Dwg. C-2021669), shall be checked with cap centering ring (A-92244). Remove socket head screws on number one end of wheel and replace with final 0-80 screws.* Inspect at 25x to 30x for possible contamination of bearings. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)

16.1 Attach thermocouple wire with calibrated Alnor meter to center of OD of stator housing.

*NOTE: All threads of 0-80 screws shall have been previously lapped.

Cover stator housing and entire rotor platform with heater blanket of of chromalox 630-2, 115 volts, 25 watts (R62) or equivalent. Place wheel in oven to preheat for approximately 30 minutes minimum at 150°F and at the same time preheat the rotor platform until Alnor meter indicates 140°-145°F. Remove wheel from oven and place in dynamic balancer. Increase the gain on amplifier until wheel just starts to rotate, note the voltage, and back off immediately. This is the breakaway voltage. NOTE: If breakaway voltage exceeds 16.5 volts check for retainer rub, high preload, etc. Increase amplifier gain to 28 volts. The wheel will rotate at synchronous speed and temperature will increase. At this speed the rotor platform temperature should be reset to 140°-145°F as indicated by Alnor meter.

16.2 Dynamically balance g the wheel until the residual unbalance is no greater than "0.10 ~~dyne-cm~~ at 12, 000 rpm. Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with delnin caps, Dwg. No. B-166037 to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope after each increment of balance. Visually inspect under 25x to 30x for contamination or physical change in bearings. Remove any trace of contamination. [illegible] removing cups clean the wheel thoroughly with suction hose.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 ~~Place in a suitable closed glass container~~ Place each in the cycling container, 2A3-10B177.

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.
Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.
Alt. Cycle: 32°F to 180°F

Equipment

Cycling Container; Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

19.1 Remove wheel from the dynamometer and place it in stand (A-88948.3). Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten with 11 to 13 oz. in. of torque. Care should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per(MC 25-304) may be used as an alternative material to tack screw heads.

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19.2 With a microscope examine the area around the screw head and wipe off off any excess Loctite. (Loctite will not cure if exposed to air).
Repeat this procedure to all 8 screws.

19.3 To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures (A-88948.3),(A-92244)
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant type A
   American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per(SCD 2021552)

20 DYNAMIC BALANCING (Final)

20.1 Place the wheel in oven to preheat for 30 minutes minimum at 150°F. Remove the wheel from oven and place in dynamic balancer. With amplifier gain adjusted to 28 volts, check the final balance of the wheel and make necessary corrections to achieve maximum residual unbalance of 0.10 dyne-cm at 24, 000 rpm.
Also measure and record the bearing noise level on(MC 25-[illegible]).

NOTE: This check should be made with the wheel at operating temperature as follows:
The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.
2) Cover the stator housing and entire rotor platform with heater blanket chromalox 630-2, 115 volts, 25 watts, (R62) or equivalent.
3) Run the wheel at synchronous speed until the Alnor meter indicates 140°-145°F.

Equipment

Micro Dynamic Balancer, Model K-1
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

29

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21.2 Clean off with vacuum hose and repeat 21.1.

21.3 Record final weight of wheel on(MC-811) (MC 25-628) and(MC 25-605).

21.4 Place the wheel in a covered glass container and store in moisture free atmosphere.

Equipment

Zeiss Stereo Microscope } or Equivalent
Vacuum hose

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure (MC 25-855)

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter (A-95721), firmly to the VS-10.

22.2 Thread lock-nut (A-92357) to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter (A-95721) very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut (A-92357) firmly against the bushing, using spanner wrench (A-92359).

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 25-50 mv. At this drive voltage the acceleration level of the float is less than 2 g's.
IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V. T. V. M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on(M.C. 811) within ± 0.25 microinch/lb.

30

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22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on(MC -811) insert wrench (A-92262)in the - SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench (A-92262), and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on(MC-811) insert wrench (A-92262), and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in(M.C. 25-605)

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ∆C, is equal to or less than 3.0 microinch/lb. If the term ∆C is greater than 3.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles).

Alternate cycle 32°F to 180°F at 4° / min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in(MC -811). If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

22.14 Using a spade oiler, or other suitable tool, apply LCA-9, (SCD 2021529) (MC 25-302) to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14. Replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on(MC 25-605)

22.19 Refer to(MC 25-855)for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder (2A3-10A180-1.2)with the Fenwal Thermistor probe, into one of the IA balance ports.

23.2 Install the float into fixture (C-87364) and attach power and thermistor leads onto provided terminal strip.

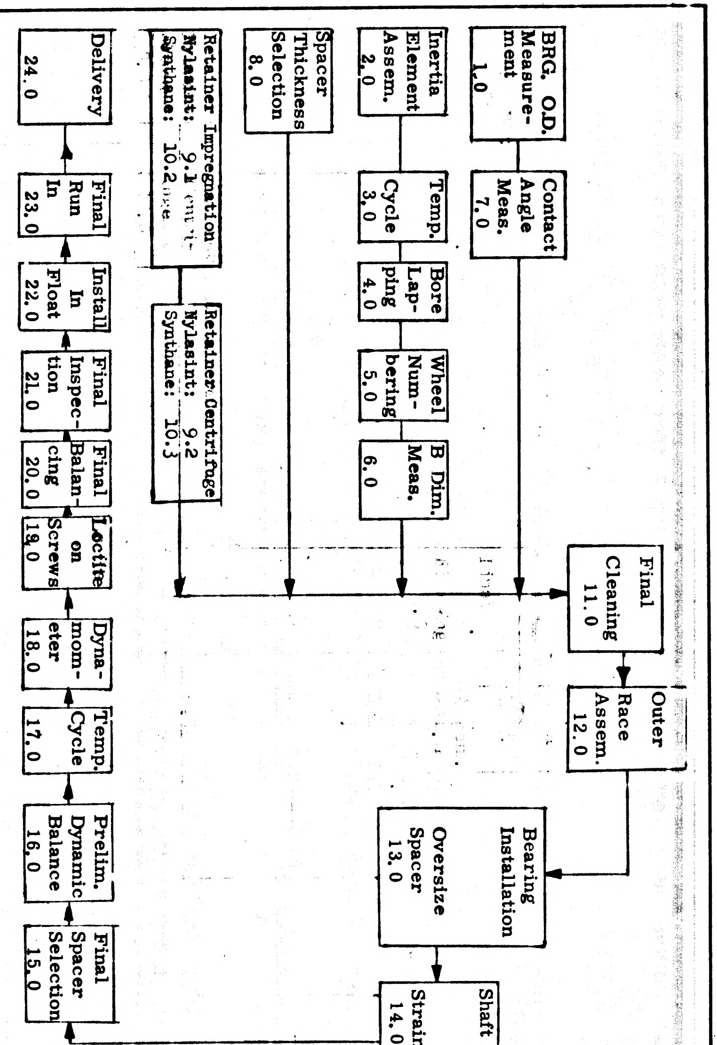
23.3 Install top plate (A-87364.1)on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 135°-140°F. With wheel at 135°-140°F turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per(MC 25-882)

24. DELIVERY

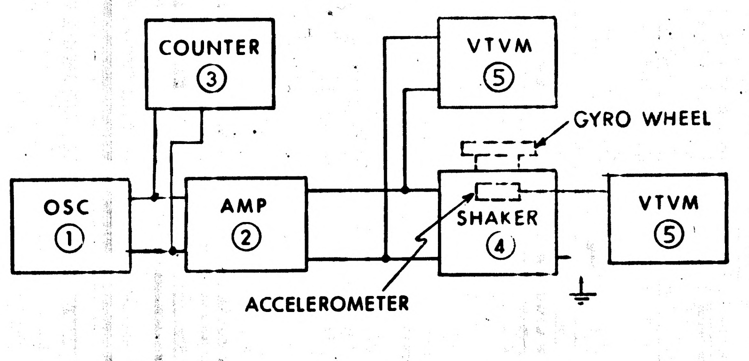
Continue float assembly per(MC 25-855)


BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation Nylasint: 9.1 Synthane: 10.2
Retainer Centrifuge Nylasint: 9.2 Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Loctite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

Fig. 1

Compliance Checking Equipment
Apollo 2 Gyro


COUNTER ③
VTVM ⑤
GYRO WHEEL
OSC ①
AMP ②
SHAKER ④
VTVM ⑤
ACCELEROMETER

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. [illegible]

Fig 2

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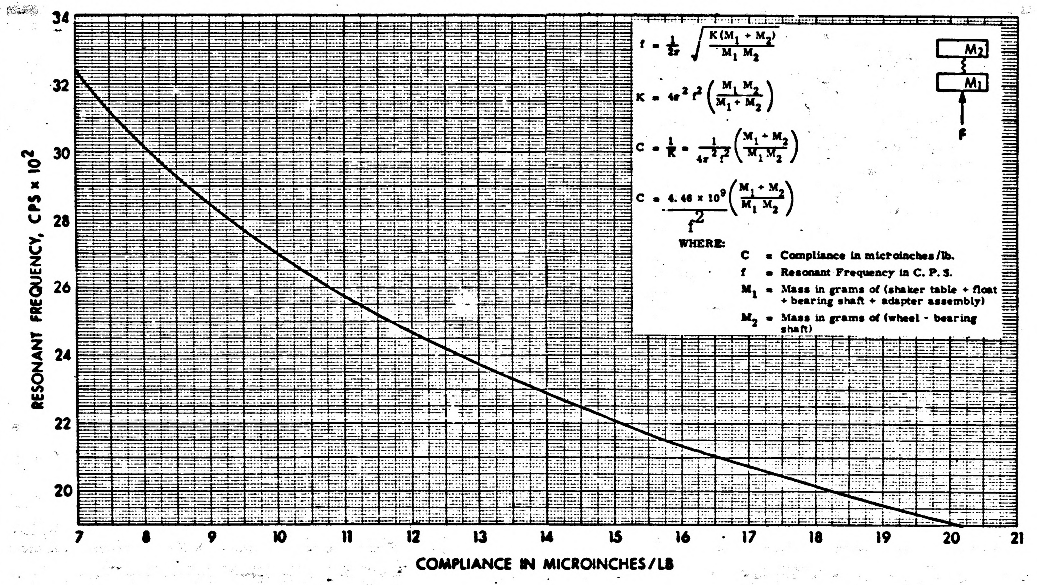
CAMBRIDGE, MASS.

PREPARED BY B. Rockower

DATE September 8, 1967

MC 25-880

SHEET 24 OF 24



$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.
f = Resonant Frequency in C. P. S.
M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)
M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

FIG 3

APOLLO II IRIG Specification
MC 25-861
Release Date 25 Nov., 1964
Release Revision A
Class A Release
TDRR 14531

ASSEMBLY PROCEDURE FOR MICROSYN

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
3/18/65	B	17643	1, 2, 3	WK.	WJR
4/21/68	C	36023	2, 3	PKJ	
12/6/68	D	37089	1, 3	MGM EA	WLS

TP#11938

This MC specification consists of page 1 to ____ and 1 to 3 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC 25-861 Rev D

SHEET 1 OF 3

ASSEMBLY PROCEDURE FOR MICROSYN APOLLO II IRIG

1.0 Coils

1.1 Assemble arbor A-104296 and coat with mold release. (DC 20 or equivalent)

1.2 Winding directions and number of turns are found on coil drawings.

B 1.3 Wrap two layers of lens tissue around arbor optional. Wind coil dry. Add two layers of lens tissue between windings on the double-wound coil assembly.

1.4 Secure last lead.

1.5 Straighten leads and cut to length.

1.6 Impregnate coils per MC-25-501.

1.7 Remove coils from arbors.

1.8 Inspect per print.

1.9 From a group of at least 50 coils, select one to use as the standard coil. Measure the percent impedance deviations (plus and minus) of the primary and secondary of all other coils relative to the standard.

Compare coils in air at 10 kcps on a comparison bridge, selecting coils within a 1% span for a microsyn assembly (Fig 1).

1.91 The double-wound coil A and B windings should be checked and impedance differences plotted A vs. B. (Fig 2). Selection of eight coils should be made in a 1% square.

Rev B 3-18-65
Rev A 10/27/64

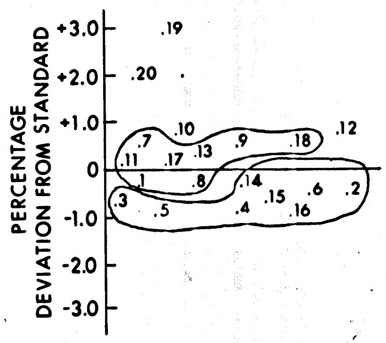


Fig 1

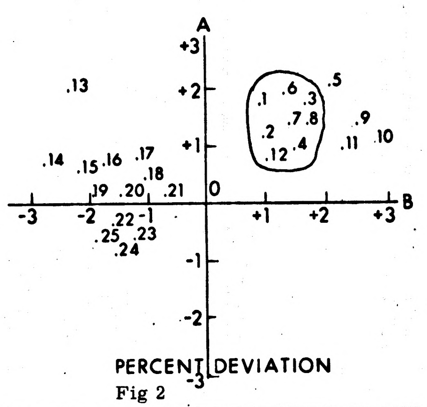


Fig 2

TDRR 14531 NOV 25 1964

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC 25-861

SHEET 2 OF 3

2.0 T. G. Microsyn Assembly 2021656

2.1 Wash stator core, printed circuit, and insulator by immersing in Ethyl Alcohol for 3 minutes and freon for approximately 10 minutes in ultrasonic cleaner.

2.2 Bond insulator and printed circuit to Durafilm side of stator core with Epon 828 per MC 25-303. Use fixture C-127576.

2.3 Place Assy. in oven and cure at 150°F for $1\frac{1}{2}$ hours.

2.4 Remove Assy. from fixture.

2.5 Place coils on stator core. Determine lead length and strip with X-Var.

2.6 Solder coil leads to pads using 60-40 solder and Kester 1571 flux. Remove flux using Kester AP-20 and acid brush or cotton swab.

2.7 Wash assembly in Ethyl Alcohol for 3 minutes and freon for 10 minutes in ultrasonic cleaner.

2.8 Check continuity, polarity, and insulation test 250VDC, 500 megohms minimum.

2.9 Hold coils back with Durofilm coated Tru-Arc rings (A-82875). Perform insulation check again.

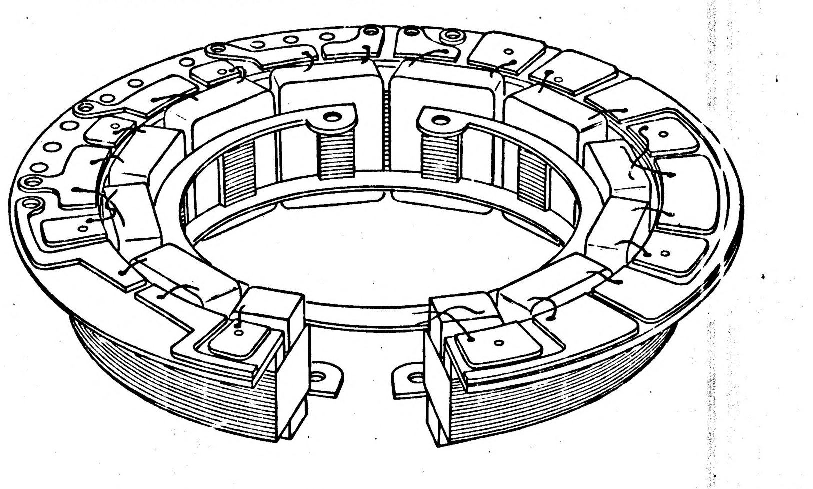

Figure 3

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC 25-861 Rev D

SHEET 3 OF 3

B 2.10 Cement coils in position with Epon 828 cement (MC25-303). Cover coil lead wires with a thin coat of Epon 828 cement.

2.11 Place assembly in oven and cure at 212°F for 1 hour.

2.12 Place tapered wooden sticks between coils 12 and 1 and between coils 1 and 2 to support reset coil while winding. Repeat for the rest of the reset coil winding. Wind reset coils.

2.13 Cut and form 0.005 Spaldo paper to fit between coils 2 and 3, 5 and 6, 8 and 9, and 1 and 12 to support winding.

2.14 Check for continuity, polarity, and grounds.

2.15 Remove one wooden stick at a time. Using thread, tie a slip knot around reset winding between coils where stick was removed and draw up to contain coil. Continue above procedure. Check 0.440 dimension.

2.16 Solder reset leads to pads using 60-40 solder and Kester 1571 flux.

2.17 Wind bias coil on Pole #9 as shown in 2021656. Solder lead ends to pads using 60-40 and Kester 1571 flux.

2.18 With an eyedropper flow Methyl Cellosolve over reset and bias coil. (Methyl cellosolve is used for solvent bonding.)

A 2.19 Place assembly in oven and cure at 212°F for 1/2 hour.

2.20 Remove assembly from oven, let cool, remove thread (see 2.15) and Spaldo paper (see 2.13) then wash by ultrasonic cleaning for 10 minutes in virgin filtered Freon.

2.21 Check unit for continuity, size (0.440 Dim), and insulation test. 250 volts DC500 megohms.

A 2.22 Weigh out 25 Grams of Silastic #881 (Dow Corning) and 1.0 Grams of Activator #881 and mix thoroughly.

A 2.23 With a suitable applicator, apply a very thin coat of the silastic to the I.D. of the microsyn stack between the poles. See figure 4. Cure for 2 hours at 160°±5°F or overnight at room temperature.

2.24 Store unit carefully for future use.

3.0 S.G. Microsyn Assembly 2021664

Same as T.G. except omit steps 2.12 through 2.21.

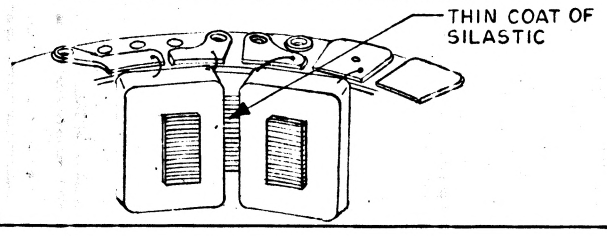


Fig. 4

APOLLO II IRIG Specification
MC 25-852
Release Date Jan. 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	NASA
5/7/65	B	18948	1, 3		
7/5/68	C	36502	All		
12/9/68	D	37098	2	MGM EA	RJJ

TP#11938

This MC specification consists of page i to ___ and 1 to 9 inclusive.

TDRR 15323 JAN 6 '65

ASSEMBLY OF SHROUD TO GYRO UNIT, APOLLO II
SHROUD END COVER ASSEMBLY

Equipment and Materials Required

450 Watt Hot Plate
50 Watt Soldering Iron Pyramid Tip
Variac
Solder - Sn 96 Ws
Solder - Sn 60 Ws
Flux -Kester 891- Kester 1571
Artist Brush #3 - Acid brushes
Trichloroethylene
Freon
Ajax, Powdered Boraxo
305A and 38-1200 lapping Compound
#00 and medium grit polishing paper

1.0 End Cover Preparation

A. Rough up the areas to be tinned on all the shroud parts, using a medium grit polishing paper, steel wool or equivalent.

B. Clean all the parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, follow by an ultrasonic rinse in clean freon for the same time period.

C. Leak check the end covers for porosity using fixture: 2A3-10B182.0 (Optional)

2.0 Tinning Procedure

A. Place the end cover on hot plate and heat to 250°F ± 10°.

B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.

C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.

D. Repeat steps B and C on inside of cover.

E. Remove from hot plate and allow to cool.

3.0 Cleaning Procedure

A. With an acid brush scrub the end cover using clean trichloroethylene.

B. Follow by scrubbing under running hot water using Ajax, powered Boraxo or equivalent.

C. Thoroughly rinse under running hot water and dry.

4.0 Assembly of Seals to End Covers

A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux.

B. Refer to 1.0 para. "B" for cleaning procedure.

C. Tin the .125 diameter on the 16 terminal seals, 2021508, with Sn-96 solder and Kester 891 flux. Clean as in step 1.0 para "B".

D. Apply 1571 flux to tinned area.

E. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position.

F. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.

G. Carefully remove from the hot plate and allow to cool.

H. Repeat cleaning procedure #3.

I. Polish the end covers using 305A lapping compound, followed by 38-1200 compound. Final clean as in step #3.

J. Seal the degassing plug hole with the aluminum ball and seal screw, Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.

K. Hi Pot - 250 volts (DC).

L. Tin the 2.443 diameter on the end cover with SN-60 solder and Kester 891 flux. Clean as in step 3.0.

M. Meggar check the assembly 250 volts DC.

5.0 Main Cover Preparation

A. Tin the 2.440 diameter and two .010 deep relief with 60-40 Solder and Kester 891 flux.

B. Refer to step #3 for cleaning.

6.0 Insert Preparation

A. Tin concave side with 60-40 solder and 891 Kester flux.

B. Refer to step #3 for cleaning.

7.0 Internal Connector Assembly

A. Check the connector assembly for shorts or opens.

B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.

C. Carefully clean all joints with trichloroethylene and artist brush, followed by a freon rinse.

D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.

E. Leak check assembly as in of step #4.

F. Apply LCA-9 adhesive (MC 25-302) over the glass seals and any exposed wires. Cure for two (2) hours minimum at 200°F ±5°.

G. Form the wires carefully at terminal to provide a 180° bend strain relief.

H. With lacing cord or shrink sleeving secure each pair of 8 wires in two places about one inch apart.

I. Make a final electrical check on assembly.

J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)

8.0 Assembly of the Shroud To Gyro Unit

A. Measure and record the bellows extension ______ in. at 135°F±5°.

APOLLO II IRIG Specification
MC 25 -882
Release Date ________
Release Revision __—__
Class __A__ Release
TDRR __35599__

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	R T Booth	
6/21/68	A	36392	3, 11	PRK	--
8/1/68	B	36605	2, 3, 5, 10	PRK	--
11/20/68	C	37036	2	PRK	--
8/28/69	D	37771	11	EA	MDH

TP#11938

This MC specification consists of page 1 to____and 1 to __11__ inclusive.

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm

n = Number of run-down time checks (no less than 8)

$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.

To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic or step power variations that are greater than 20 milliwatts. The maximum variation in mean power level shall not exceed 50 mw. Figs. 1a, b, c represent acceptable power traces. 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.

The maximum allowable trace width during the monitoring period for an acceptable wheel is 40 mw. The maximum allowable variations in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11-15	20
15-20	25
20-25	30
25-30	35
30-35	40
35-40	40

2.2.2 Provisionally Acceptable Power Trace

There are two categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 [illegible] Level Wander

Fig. 2 is typical of a power trace exhibiting a [illegible] of the [illegible] level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than twice during the 100 hour qualifying period as defined in section 1.2.

2.2.2.1 Test Equipment Influences

Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.2 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, h), equipment malfunction (Fig. 3i).

B. Allow the gyro to cool down and remain at room temperature during the shrouding operation.

C. Carefully inspect the OD. of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

D. Align the open ports in the main cover with the +SRA and +IA gyro axis.

E. Install the end cover assembly on the unit, carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

F. Perform an electrical check for correct resistances, opens and grounds.

G. Apply a minimum amount of 1571 Kester flux to main cover- end cover joint with a piece of solder or a small artist brush.

H. With a 50 watt soldering iron (Pyramid Tip) make the joint between the main cover and end cover.

I. Excess solder can be removed with a sharp edge dental tool, and hard rubber abrasive eraser.

J. Repeat steps "E" through I for remaining end cover.

K. Clean the joints by brushing with an acid brush and clean trichloroethylene, followed by a brushing with clean freon.

L. Perform complete electrical check of unit.

9.0 Leak Check of Shrouded Unit

A. Carefully assemble the unit to the leak check fixture, C-127683.

B. Seal off the exposed end with the aluminum ball (17S-T4) and #2-56 x 3/32" long sealing screw. Leak check this end of the unit. Maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

C. Remove seal screw and aluminum ball.

D. Repeat steps "A" through "C" for the opposite end of unit.

10.0 Decals

A. Clean the ends of the shroud covers with a Kimwipe dampened with trichloroethylene. Remove the protective backing from the T. G. decal and fasten the decal to the T. G. shroud end cover. Aligning the IA arrow such that it is pointing toward the degassing seal. Smooth out the decal using finger pressure to eliminate ridges, air pockets, etc. Repeat the operation for the S. G. decal aligning the lettering such that it reads in a direction which is perpendicular to the degassing seal.

11.0 Preliminary Testing

A. Refer to MC 25-905 for preliminary testing procedure.

12.0 Final Shroud Sealing After Preliminary Testing

A. Cool gyro to room temperature.

B. Apply a minimum of Kester 1571 to the two (2) 0.010 inch deep reliefs on the sleeve and concave surface of the inserts.

C. Position the inserts on the sleeve so as to follow the general contour of the 2.460 diameter.

D. With a 50 watt soldering iron and Sn-60 solder, make the joint between the sleeve and inserts. Remove excess solder as before. Clean the joints with an acid brush and trichloroethylene, followed by a brushing with clean freon.

13.0 Final Leak Check of Shrouded Unit

A. With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S. S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683. Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the

terminals, ports and main seam at the end with helium. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

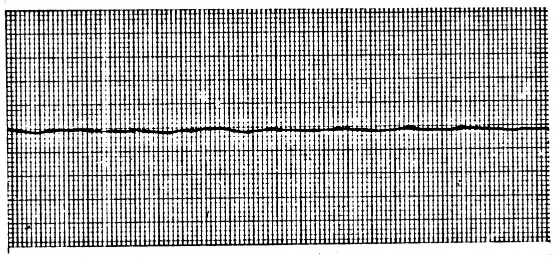
B. Remove the sealing screw and aluminum ball from the unit.

C. Invert the unit and leak check as before.

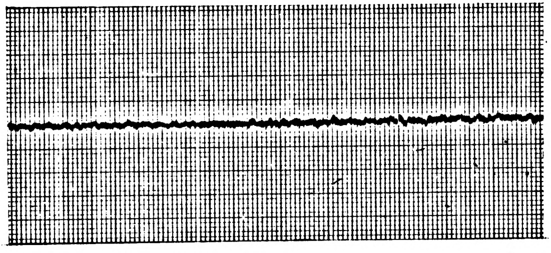
D. With the unit still on the leak check fixture and 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug. Remove the unit from the fixture and retorque both set screws to 28-30 in. oz.

E. Final test per MC 25-905.

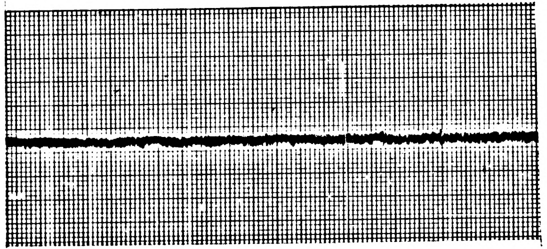
F. Store in a 135° ±5°F. oven awaiting delivery.



1a



1b

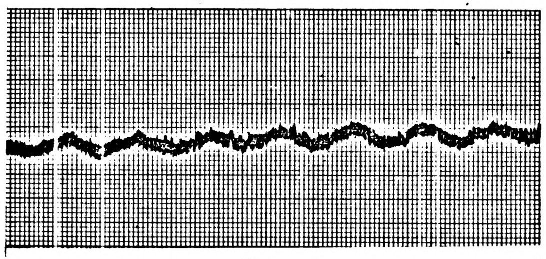


1c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sce ± 15%

Fig. 1 Acceptable Power Traces

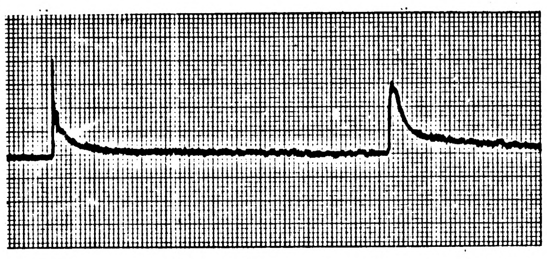
Fig. 2a Deleted



2b

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

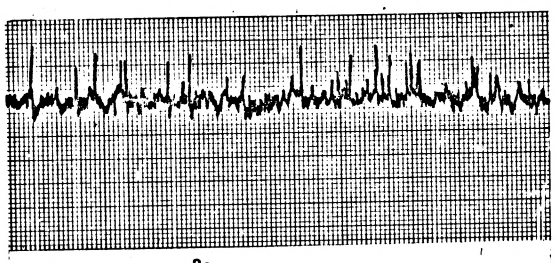
Fig. 2 Provisionally Acceptable Power Traces.



2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

Fig. 2c Provisionally accepted power trace due to oil jog.

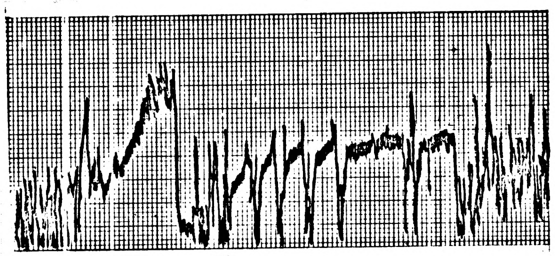


3a

Probable Cause	
Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer superimposed on a rough and irregular power trace.

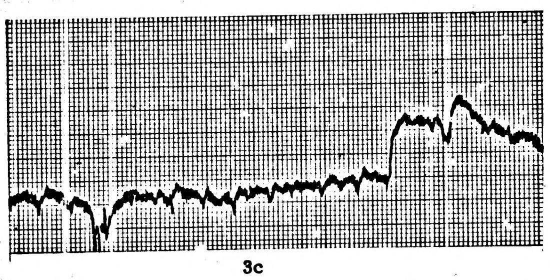
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.



3b

Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.

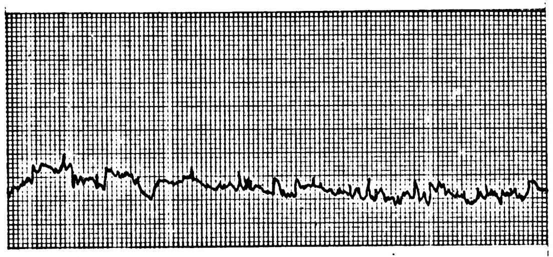


3c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces

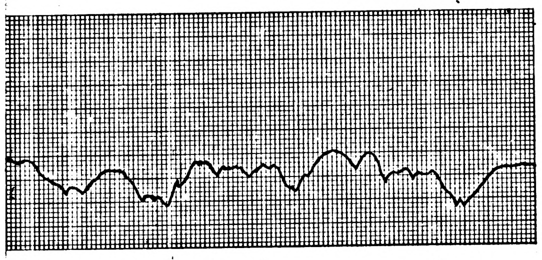


3d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced power variation.



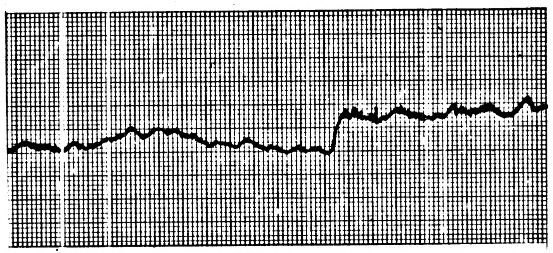
3e

Probable Cause
Varnish
Debris

A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

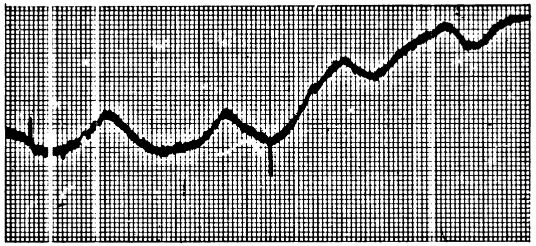


3f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



3g

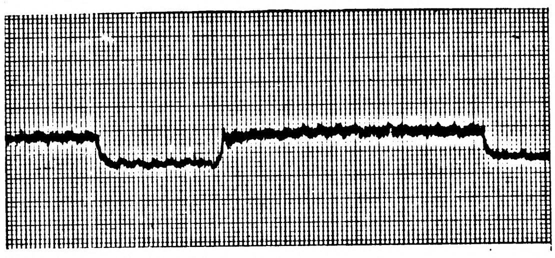
Probable Cause

Varnish

This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

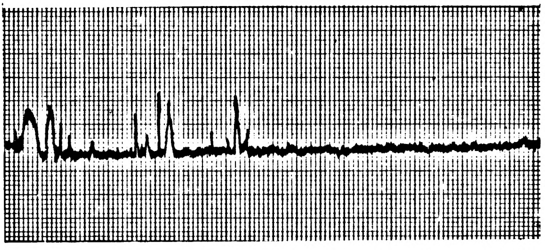


3h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light ot control the angular velocity of the ball group in one bearing.



3i

Probable Cause

Squeal

[illegible]

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

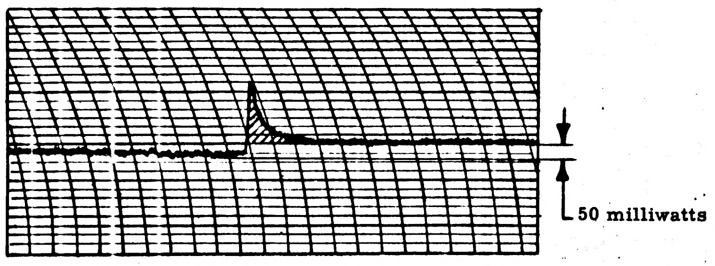


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.2.

APOLLO II IRIG Specification
ATP 2021500, MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
12-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13	2/24/65	2/4/65
9-20-65	C	22893	5, 6, 7, 9, 10, 11, 12		
10-8-65	D	23195	11, 12		N/A

This specification consists of pages i to ____ and 1 to 13 inclusive.

Rev B 12/21/64
Rev A Revised and Rewritten 10-24-64
Rev C 9/9/65

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

1. Sub-Assemblies and Parts to be Demagnetized
   - A. All magnetic parts prior to final assembly.
   - B. Float Assembly, Dwg. 2021619.
   - C. End housing assemblies, Dwg. 2021663 and 2021649.
2. Float Preparation
   - A. Cementing the rotors to the stub shaft.
     - 1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
     - 2) Assemble the rotors to the float to insure proper seating.
     - 3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
     - 4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
     - 5) TG rotor should be aligned per MC 25-618 step A, 11.
     - 6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
     - 7) Place assembly in oven and cure for 1-1/2 hours minimum at 150° ± 5°F.
     - 8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

TG End ______________ TIR
SG End ______________ TIR

Maximum allowable runout on either end 0.0005 TIR.

3. Float Measurements
   - A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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4. Flotation
   - A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

Weigh the float and record ____________gm.

   - B. Determine the neutral buoyancy, end for end and rotational balance as follows:
     - 1) Place the float in an oven at 140°F for about 15 minutes.
     - 2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
     - 3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
     - 4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

B Weight in air of solder on holder at TG end ________________.

B Weight in air of solder on holder at SG end ________________.

Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

Weight (in air) added to TG end ______________
Material ______________

Weight (in air) added to SG end ______________
Material ______________

Total float weight in air ______________

     - 5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

   - C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

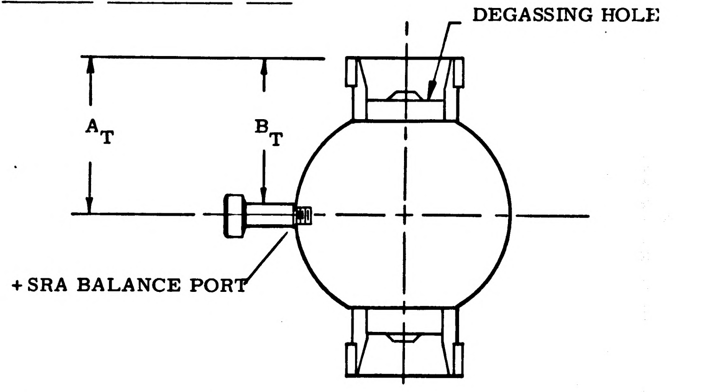
NOTE: Plummets may be used to check fluid density while performing flotation.

   - D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.
   - E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.
   - F. Leak check and record ________________ atm-cc/sec.

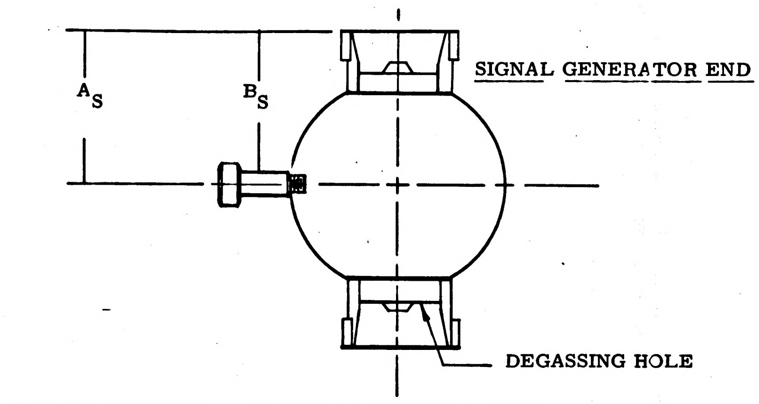
Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

FLOAT MEASUREMENTS

TORQUE GENERATOR END



A_T ____ = B_T ____ + .1250



A_S ____ = B_S ____ + 1250

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5. Main Housing Preparation
   - A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.
   - B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly
   - A. End Cap Assembly
     - 1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.
     - 2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.
     - 3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.
     - 4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.
   - B. Thermistor Installation
     - 1) Procure thermistor per 2021518.
     - 2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)
     - 3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation
   - A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.
   - B. Check the fit of the damping blocks to the main housing.
   - C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:
     - A. K&D #100 round nose for spreading.
     - B. K&D #106 flat for staking eyelet to counterbore.
     - C. K&D #108 flat for staking eyelet head.

- D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.
- E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.
- F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.
- G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.
- H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation
   - A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.
   - B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring
   - A. Mount a damping block assembly to fixture B-92316.
   - B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.
   - C. Lay a piece of flat pegwood across the center of the flex lead.
   - D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.
   - E. Repeat A through D for the second damping block.

10. Air Gap Measurements
    - A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing
    - A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_s in the support block A-118435.

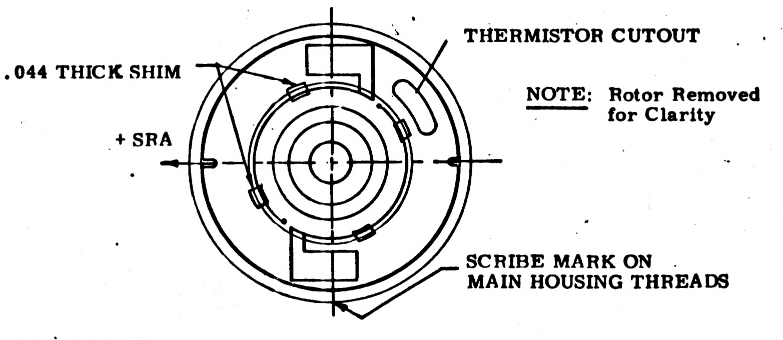
Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

- B. Carefully lower the float into the main housing, with the torque generator up, the B- facing the assembler and + SRA to the left.
- C. Insert the dummy stop pin A-92284 into the + SRA balance port, and secure it with a locking screw.
- D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer.

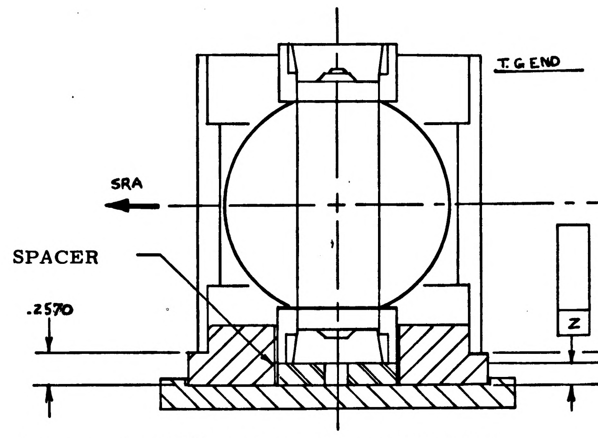
12. Torque Generator End Damping Block Assembly
    - A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.
    - B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.
    - C. Use the two shims A-87335 to support the weight of the flex lead as shown below.
    - D. Apply a small amount of #1571 Kester flux to each float terminal.
    - E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

      Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

      Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.



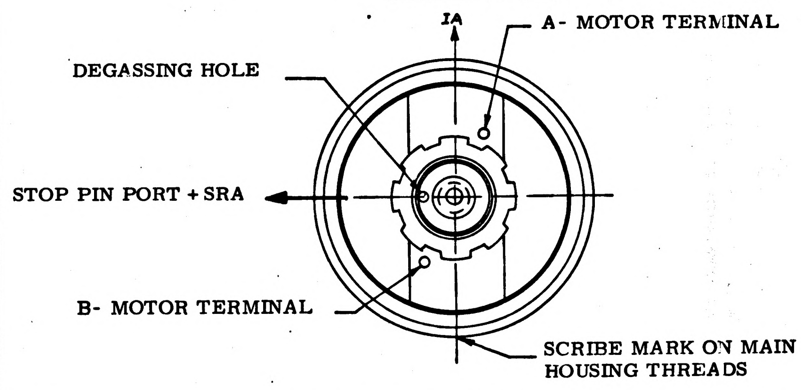
NOTE: Rotor Removed for Clarity



Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer - thickness Z_s as indicated below.

Z_s = 0.2570 + C_3 - A_s

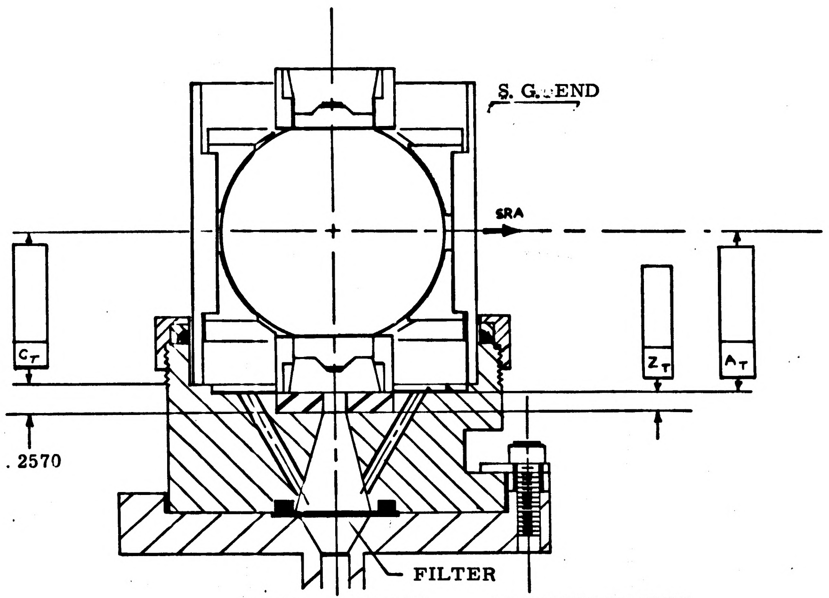


CC 13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



Z_T = 0.2570 + C_T - A_T

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O.D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O.D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

C B H. Solder the flex leads to the spring tab and float terminals as before.

CC 14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 50 microinches.

E. Apply Damping Fluid (MC 25-612) sparingly to the pivot body and then wipe thoroughly with lens tissue. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

CB 16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut.

CB 17. Dry Centering

A. Dry center the instrument as per MC 25-854.

CB 18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end D cap clamp to 60 in-lbs. Invert unit and repeat above procedures.

CB 19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page # 13.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964

MC 25-853

SHEET 12
OF 13

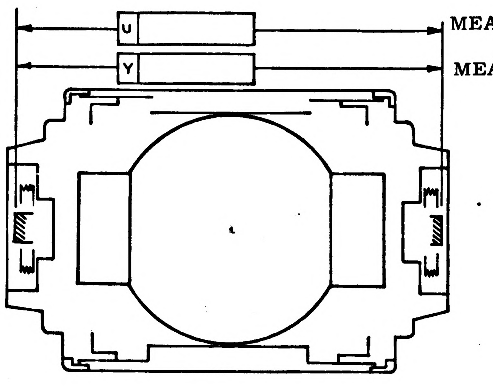
CB 20. Bellows Measurement

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)— ☐ Grams

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CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64

MC# 25-853

SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_Y					
S_H TO S_L						T- TO T_Y					
S_L TO SSQ1 SEC						T_Y TO T_C					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT

A- TO A+					
B- TO B+					
A- TO B-					
A+ TO B+					

APOLLO II IRIG Specification
MC 25-854
Release Date 13 Nov. 1964
Release Revision A
Class A Release
TDRR 14363

Apollo II IRIG
Dry Centering Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/13/65	B	18306	1	WK	WJR
1/25/66	C	27051	2	WK	[illegible]
3/22/66	D	27337	2	WK	A. C. METZGER

TP#11938

This MC specification consists of page 1 to ___ and 1 to 5 inclusive.

Rev B 4-13-65
Rev. A 11-9-64 Revised and Rewritten

APOLLO II IRIG DRY CENTERING PROCEDURE

1. Preliminary

1.1 Mount unit in Fixture D-87262 with +SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Figure #1 and check continuity through cabling.

1.3 Heat unit to 135° ± 5°F and maintain temperature.

1.4 Excite gyro per Figure #1 at 10.0 volts ± 1%.

1.5 Center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position.

2. Angular Alignment of Microsyns

2.1 Rotate the gyro about OA from +SRA down to +SRA up and back to down. Observe radial signal relative phases. A phase reversal indicates radial freedom, which must be attained before continuing.

2.2 Drive the float electrically between angular stops by torquing per Figure #1 insert, and ensure that the ±IA and +SRA balance paddles are rotationally centered in the 12-72 balance weights. Nominal torquing current required is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 87262.2 until the angular stop voltages are equal within 10 millivolts.

B 2.4 With the T. G. excited as a signal generator as in Figure #1, note the magnitude and phase of V_o. Rotate the T. G. end housing until V_o has the same relative phase as in MC 25-860 Step 3.5, and is is at the null voltage within 2 mv, or Vo within ± 2 mv of MC 25-860, Step 3.5 if the latter value is higher than null.

TDRR 14363 NOV 18 1964

2.5 Using an adjustable C- clamp as a tool, clamp the end housing tight to the main housing. The parts should bottom to give line-on-line fit when examined with an eye loupe.

2.6 Repeat Step 2.1 and note phase and magnitude of radial signals. The maximum acceptable centering ratio is 6:1.

3. Setting End Shake

3.1 With the unit in the OA vertical up position, adjust the T. G. pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 20±1 ma. Adjust the S. G. pivot, if necessary, to ensure that the float does not become locked between the pivots.

C 3.2 Use the axial sensitivity of 0.27 ma/0.0001 in. and retract the T. G. pivot 0.00060 inch (1/2 the total end shake) by monitoring the change in the T. G. suspension current.

3.3 Advance the S. G. pivot until it just bottoms.

3.4 Slowly rotate the gyro until the OA is vertical down.

C 3.5 Retract the S. G. pivot until the suspension currents are equal and then using the same calibration, retract the S. G. pivot .00060 inches by monitoring the change in the S. G. suspension current.

D ALLOWABLE END SHAKE 0.0009 to 0.0015

3.6 With the gyro in the OA vertical position, apply a very small amount of LCA-9 adhesive (MC 25-302) to the pivot and end housing at three points 120° apart. Cure per MC 25-302. Rotate to the S. G. up position and repeat the cementing procedure.

3.7 Remove the pivot adjustment fixtures.

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---

4. Cementing Clamping Caps

4.1 Recheck angular stops and microsyn alignments, re-adjusting as necessary.

4.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

4.3 Coat the threads on the clamping cap with Epon 828 and assemble to the unit. Wipe off excess cement.

4.4 Check the angular centering and make any necessary adjustments before cement sets up. Keep the unit OA vertical for one-half hour with the cemented end up.

4.5 Repeat 4.2 and 4.3 for other end and cure at 137°F for one hour.

5. Final Alignment Checks

5.1 Repeat 2.1 recording magnitude and phase of the radial signals. Maximum acceptable centering ratio is 6:1.

5.2 Recheck microsyn alignments and end shake. Record end shake currents and S. G. stop voltages.

5.3 Refer to MC 25-853 for continuation of final assembly.

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APOLLO II IRIG Specification
MC 25-884 REV D
Release Date ____
Release Revision --
Class A Release
TDRR 35599

NYLASINT RETAINER PROCESSING SPECIFICATION

	Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
Ⓜ	13 FEB 68	—	35599	INITIAL RELEASE		
Ⓜ	3-22-68	A	35932	1, 2, 3		--
Ⓜ	8/1/68	B	36622	1-3		--
Ⓜ	12/10/68	C	37111	3	MGM EA	WLS
	8/28/69	D	37770	2, 4	EA	MDH

TP#11938

This MC specification consists of page i to ___ and 1 to 4 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 35932 MAR 22 1968

PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev B
SHEET 1 OF 4

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (Material per Dwg C-2021819) with V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg C-2021816. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in. hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 20X magnification. Repeat steps a, b, or c, if necessary.

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PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev D
SHEET 2 OF 4

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150° -160°F and 29 1/2 in. hg. minimum.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0 ± .5 grams/minute at a line pressure of 80 psi approx. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time(Tolerance: ±5 sec)
Ball Pockets	2 min. each pocket
Outer Diameter	2 min. total
Edges	2 min. each edge
Inner Diameter	20 sec. total

NOTE: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period)

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° ± 150°F and 29-1/2 in. Hg minimum.

f. Equipment
S. S. White Industrial Abrasive unit
model G
201 East 42nd Street
New York, N. Y. 10017 or equivalent
NOTE: Handpiece 351-1793y (approx .040 dia) without nozzle attachment shall be used as a nozzle

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

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PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev C
SHEET 3 OF 4

c. Finally inspect retainer for absence of burrs, contamination, and damage under 20X magnification.

d. Holes from pull out of solid nylon inclusions will be permitted on the I.D. surfaces and side edges of the retainer. Pull out at the edges of the ball pocket surfaces which intersect the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. and O.D. surface and the ball pocket surface. The depth of blend may not exceed 0.010 inches into the ball pocket or the O.D. or I.D. surface. (See fig.1).

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material. No inclusions will be permitted where ball makes contact in pocket. NOTE: Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown and black) inclusions are acceptable only if they are imbedded below the surface of the retainer surface.

8. Oil Absorption Test

a. Check retainers for oil absorption test per MC 25-911.

b. After oil absorption test reclean the retainers per paragraphs 6c, 6d, and 6e of this specification.

9. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage enviroment.

c. The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.

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CAMBRIDGE, MASS.

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964

MC 25-854

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of 5

DATA SHEET

2.4 Information from MC 25-860, 3.5

E_o = ___________ mv O phase

Measurements from 2.5

E_o = ___________ mv O phase

5.1 SGX ___________ TGX ___________

SRA up

SGY ___________ TGY ___________

SGX ___________ TGX ___________

SRA down

SGY ___________ TGY ___________

Centering Radios

SX ___________ TX ___________

SY ___________ TY ___________

5.2 Final suspension currents

OA up

I_{ms} ___________ ma

I_{mt} ___________ ma

OA down

I_{ms} ___________ ma

I_{mt} ___________ ma

Cw Stop ___________ mv

CCw Stop ___________ mv

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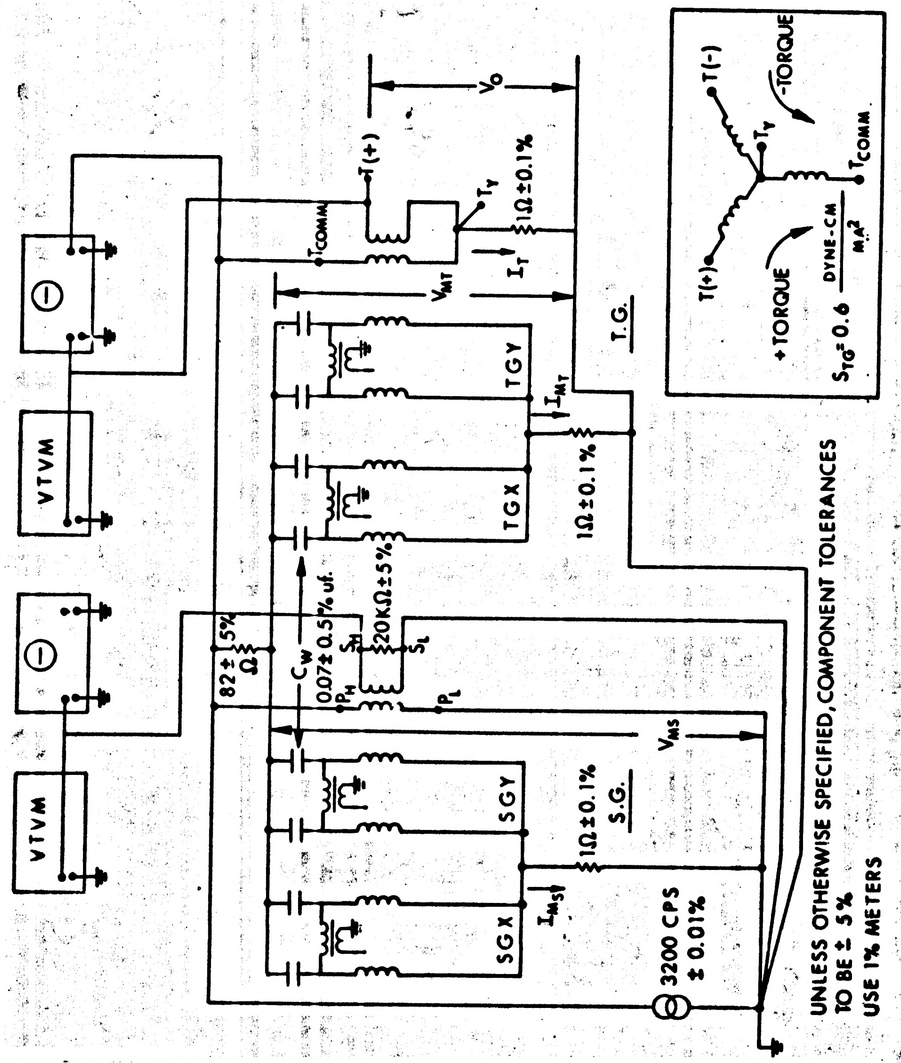
CAMBRIDGE, MASS.

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964

MC 25-854

SHEET 5
OF 5



VTVM
VTVM
V_o
T(+)
T_{COMM}
T_Y
1Ω±0.1%
I_T
V_{MT}
T.G.
TGY
TGX
I_{MT}
1Ω±0.1%
82±5% Ω
C_W
0.07±0.5% uf.
20KΩ±5%
S_H
S_L
P_H
P_L
V_{MS}
SGY
SGX
1Ω±0.1%
S.G.
I_{MS}
3200 CPS ± 0.01%
T(-)
-TORQUE
+TORQUE
T_{COMM}
S_{TG} = 0.6 $\frac{\text{DYNE-CM}}{\text{MA}^2}$

UNLESS OTHERWISE SPECIFIED, COMPONENT TOLERANCES
TO BE ± 5%
USE 1% METERS

Figure #1

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PREPARED BY: B. Rockower
DATE: October 10, 1967
MC 25-884 Rev D
SHEET 4
OF 4

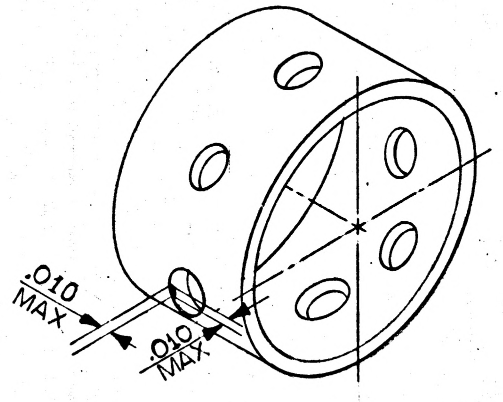

FIG 1
BALL POCKET BLEND

APOLLO II IRIG Specification
MC 25-855
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4-30-65	B	18829	1, 4, 5	WK	[illegible]
3/21/68	C	35603	4, 5	DRK	See TDRR
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8 (DELETED)	DRK	See TDRR

This MC specification consists of page 1 ~~to~~ and 1 to 7 inclusive.

TP#11938

TDRR 36614 AUG 1 1968

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 1
OF 7

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.

2. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA ________ -SRA ________

Record I. D. of hemisphere shaft bore

+SRA ________ -SRA ________

Average Interference

+SRA ________ -SRA ________

3. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

A 4. Clean all the float parts in clean trichloroethylene for a minimum of three (3) minutes, followed by an ultrasonic rinse in clean freon for the same time period.

Rev A 10-26-64
Rev B 4-30-65

5. Weigh all the float parts and record information on sheet #6.

6. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in Acetone followed by cleaning as in step #4.

7. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8. Measure and record the following:

A) O. D. of stator ________

B) I. D. of gimbal ________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".

C) Average interference ________ (.0001-.0003).

TDRR 14531 NOV 25 1964

TDRR 36614 AUG 1 1968

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
MC 25-855
SHEET 2
OF 7

9. Install the motor stator into the gimbal as follows:

   A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.

   B. Place the bushing A-92287 into the pressure plate.

   C. Assemble the motor stator to the pressure plate A-87423.

   D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

   E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O. D.

   F. Remove the gimbal and fixture base from the hot plate.

   G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.

A H. Remove fixture and check centering of the stator in the gimbal. Check continuity. To be centered to within .005".

A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

10. Weigh gimbal and record ________ gms.

A 11. Grind I. D. of motor stator as per drawing 2021625.

12. After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol (room temperature or warm 90°F ± 5°F) followed a thorough rinsing in clean freon.

13. Weigh gimbal and record ________ gms.

A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

14. Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.

   A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ± 5° oven for 1/2 hour.

   B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F ± 5°.

TDRR 36614 AUG 1 1968

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover
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   C. Repeat step "B" on opposite end of gimbal.

   D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F ± 5°F.

   E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F ± 5°F.

15. Install .062 diameter ball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10 x 10^{-8} ATM cc/sec. Leak rate ________

A 16. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt. cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10 x 10^{-8} ATM cc/sec. with a dwell time of one (1) hour at the extremes. Leak rate ________

17. Remove the sealing screw and .062 diameter ball from the degassing hole. Reassemble the #2-56 sealing screw to the gimbal. DO NOT TIGHTEN.

18. Assembly of wheel to float

   A. Thoroughly clean all float parts and fixtures to be used in clean filtered freon. Follow by a thorough vacuuming.

   B. Mount the +SRA float hemisphere on fixture B-88921 and place on thermostatically controlled hot plate set to 350°F + 15°F and allow to heat for five or ten minutes.

   C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide in-to the hemisphere until it bottoms.

A NOTE: Nylon gloves or finger cots to be worn when handling wheel.

19. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

20. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

21. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.

22. Heat the -SRA hemisphere as in "B" of step #17.

23. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

24. Carefully assemble the wheel and +SRA hemisphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

25. Balancing the float in Air

A A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

26. The float at this time is complete except for the rotors and balance weights. Weigh the float and record _______________ gms.

27. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T. I. R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 3.

B 28. Refer to MC 25-803 or MC 25-869 or MC 25-880 for instructions on setting the +SRA bushing.

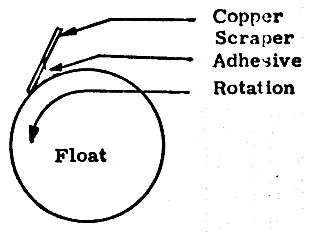
B

29. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ± 5°. oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.

Rev. B 4-30-65 (Revised & Retyped)



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 175°F ± 5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ± 5°.

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms.

B. Place a 2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

The following alternate procedure may be used:

Install float in fixture as described above. Draw a vacuum of 15" Hg and then admit helium to 0" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as above.

C. Weigh the float and record _______________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. _____________ gms.

31. Leak check and record __________________ atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min. with a dwell time of one (1) hour at the extremes.

33. Leak check and record __________________

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

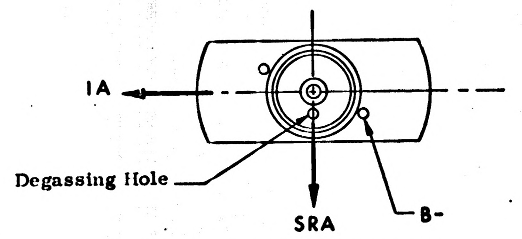
A 34. Refer to MC 25-803 or MC 25-869 or MC 25-880 for float run-in requirements.

FLOAT WEIGHT RECORD

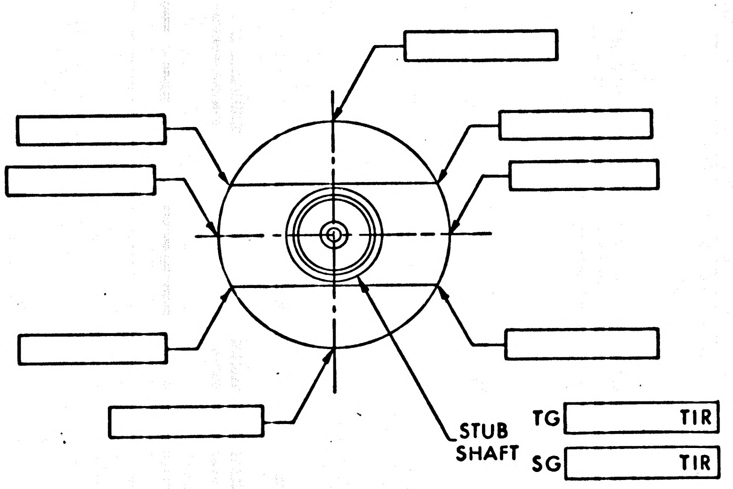
Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
A-87287	4	Power Lead-in		.092	
A-107251	8	Balance Weight (Final Rot. Adj.)		.740	
A-107252	4	Balance Weight Spring		.018	
A-87391	1	Centering Shim		.013	
B-87374	2	Bushing		1.676	
Comm'l.	1	#2-56 Sealing Screw		.037	
Comm'l.	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
C-87373	2	Hemisphere		14.701	
D-112977	1	Gimbal		26.051	
B-87289	1	Motor Stator (Finish Ground)		18.800	
C-118575	2	Rotor Assy.*		32.968	
C-87341	1	Wheel Assy.		37.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
A-84046	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		134.000	

*Rotors installed at final assembly.



(View from T. G. End)



Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC 25-857
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
1-18-64	B	15625	1, 5	WK.	
2-12-65	C	16762	1, 2, 3, 4, 5		
7/5/68	D	36503	All		See TDRR

TP#11938

This MC specification consists of page 1 to ~ and 1 to 5 inclusive.

Rev A 9-21-64
Rev B 1-18-65
Rev. C 2/12/65

A

END HOUSING ASSEMBLY, APOLLO II IRIG

I. Terminal Seal Assembly

A. A. Clean the end housing and terminal seal ultrasonically in trichloroethylene for a minimum of five (5) minutes, followed by an ultrasonic rinse in clean freon for the same time period.

A B. Leak check terminal seal using fixture B-123696 max leak rate 0.10×10^{-8} ATM-cc/sec. Leak rate ________ (Above step is optional.)

3. Place the end housing in the end housing holding fixture.

4. Place this assembly on a thermostatically controlled hot plate and heat the end housing to 160°F ±10°F for approximately ten (10) minutes.

5. With a watchmaker's spade oiler or some other suitable applicator, apply LCA-9 (MC 25-302) to the end housing as shown below.

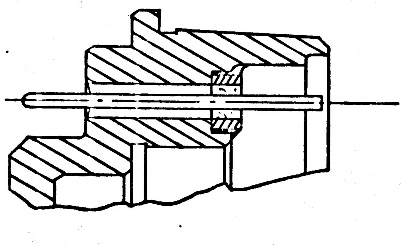


Figure 1.

A 6. Insert the terminal seal into the end housing.

7. Press the terminal seal into position with a small piece of sharpened pegwood to force the adhesive around the terminal and into the sixteen (16) 0.070" diameter holes in the end housing.

8. Center the terminal seal in the end housing using fixture C-127580.

9. Place the end housing holder and end housing in a 200°F oven and cure for two (2) hours.

10. After the initial two (2) hour cure, remove the assembly from the oven and cool to room temperature. As the 0.070" diameter holes are too deep to be completely filled with the adhesive, it is necessary to back-fill the pins. Feed C-7 or Epon 828 adhesive into the holes and around the pins carefully. The adhesive should be flush or below flush with the bottom of the chamfer on the 0.070" diameter hole. C

C 11. Cure Epon 828 adhesive for 1 1/2 hrs. at 150°F. Clean any excess adhesive from O. D. of pins. Cure C-7 per MC 25-301.

12. Assemble the end housing to the leak check fixture A-87326 and leak check. If the leak rate is greater than 2×10^{-10} ATM-cc/sec; the assembly should be rejected.

L. Cycle the assembly from 0°F to +180°F four times at a maximum rate of 3°/min. with a dwell time of one (1) hour at extremes.

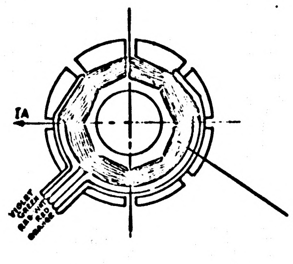
14. Repeat Step #12.

A 2. Assembly of Inner Suspension to End Housing

1. Visually inspect the inner suspension 2021657 paying particular attention to solder connections and any loose wires that could be damaged during potting and grinding operations.

2. Perform resistance measurements and record the requested information on MC 25-858.

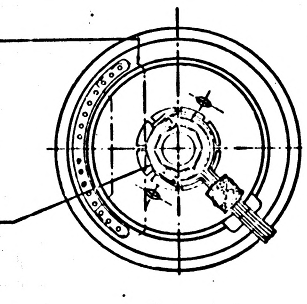
C. Shape and group the wires of the suspension as shown in the sketch in Figure 2.



A Coil with identifying mark.

C D. Apply Epon 828 or LCA-9 adhesive to the suspension seating shoulder of the end housing at three places 120° apart.

A 5. Assemble the inner suspension to the end housing, aligning the registration mark along the -IA axis using fixture A-113109. See sketch below.



Alignment Fixture
A-113109

Identifying Mark

C 6. Cure for 1/2 hrs. at 150°F.

7. Group the five (5) suspension wires as shown in the sketch of Note 5 and hold them in position with positioning fixture A-113235.

H. Bond the wires to the floor of the end housing using LCA-9 adhesive (See MC 25-302). Do not apply a heavy layer of adhesive over the wires. The outline of the wires should be just visible through the adhesive (0.035 max adhesive build-up). Cure the adhesive.

Note: Steps "D" through "H" may be performed in one operation.

3. Assembly of the Microsyn to the End Housing

C A. Coat the body and glass of the terminal seal with EPON 828. Cure for 1 1/2 hours minimum at 150°F ± 5°.

2. Perform a resistance check of the microsyn, and record on MC 25-858.

3. Check the microsyn for loose wires, loose or cold solder connections, solder build-up, burrs or cement build-up on the O. D. or windings.

*C. Carefully fit the microsyn into the end housings aligning the 16 holes in the microsyn printed circuit with the pins and feeding the inner suspension wires through the slot in the printed circuit. Be sure the microsyn is seated. Perform an electrical check. Apply a small bead of EPON 828 to the bottom of the microsyn O. D. three places 120° apart.

5. Solder the 7 short pins to the printed circuit using 60-40 solder and Kester 1571 flux. Carefully clean the solder joints with Kesters AP-20 or with an artists brush dipped in trichlorethylene and rinse with freon. Perform a resistance measurement and record.

*Note: Use of adhesive on microsyn O. D. optional.

TDRE 36503 JUL 5 19[illegible]

PREPARED BY: David N. Kupelian
DATE:
MC 25-857
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4. Assembly of Printed Circuit and Mumetal Shield

A 1. To insure solderability, remove surface film on buttons 2021655 either chemically or mechanically.

AC B. Tin the top of the pads of printed circuit 2021652 (around the 0.062" diameter plated through holes). Clean with an artist's brush dipped in trichloroethylene and rinse with freon. SN-96 solder.

C. Apply a small amount of Kester 1571 flux to shoulder of the button. Position the buttons in the printed circuit and using a 37 1/2 watt iron, apply heat to the top of the button in order to form a solder fillet at the base. Clean as in step 2. SN-96 solder.

4. Cement the mumetal shield to the back of the printed circuit with Epon 828 adhesive and assemble to bonding fixture B-87377. Cure for 1 1/2 hours at 150°F.

5. Any excess adhesive on the O. D. of the assembly can be removed by using a medium grit emery paper. Rinse in freon.

5. Assembly of Printed Circuit to End Housing

A. Apply three tacks, at 90° intervals, of LCA-9 or Epon 828 adhesive to the end housing mounting shoulder at the +SRA, -SRA, and +IA axes.

2. Assemble the printed circuit to the end housing by feeding the 5 inner suspension wires through the slot and aligning the nine terminal pins with the holes of the printed circuit.

C. Solder the (9) terminal pins with 60-40 solder and Kester 1571 flux. Clean as in Section IV, 2.

NOTE: The height of all solder joints should be kept to a minimum to insure complete coverage during the potting operation.
Step "A" of section 5 optional. Adhesive can be applied after assembly of printed circuit. [illegible]

D. Cut the (5) inner suspension wires so that the end of the wire will not reach the far end of the printed circuit pad. Strip the wire back as far as the slot in the printed circuit. Flare and flatten the wire strands and solder the wires to the printed circuit.

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PREPARED BY: David N. Kupelian
DATE: February 25, 1964
MC 25-857
SHEET 5
OF 5

VI. Microsyn Stator Potting

1. Refer to MC 25-507 for potting procedure. Follow MC 25-858 for the post cure and temperature cycling procedure.

2. Leak check the potted assembly using fixture A-87326. Maximum acceptable leak rate is 0.5×10^{-8}atm-cc/sec.

7. Microsyn Grinding

1. Place a terminal pin protector A-109464 over the pins. Finish grind per drawings 2021649 and 2021663.

B. After the grinding operation, remove the potting material from around the two motor buttons so that the potting compound is below the top of the button. Remove sharp edges, burrs. Polish the motor buttons with fine polishing paper charged with 305 A lapping compound.

C. Carefully inspect the assembly under a microscope for any loose potting, smeared metal around pole faces, cracked potting or voids.

D. Thoroughly clean the end housing with an acid brush while immersed in warm 90°F ± 5° clean varsol. Follow by a rinsing in clean freon.

VIII. Pivot Bore Measurements

1. Using ball gages (A-122143) determine the pivot bore size and record ______________.

9. Test the end housings and rotors per MC 25-859 and MC 25-860. After testing the matched components must be kept together.

APOLLO II IRIG Specification
MC 25-848
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Float Freedom Test

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
1/25/65	D	25502	Revised & Retyped	1-25-66	C. METZGER

TP#11938

This MC specification consists of page 1 to____and 1 to 3 inclusive.

Float Freedom Test

The gyro shall be at Operating Temperature, mounted on a servo table with table axis vertical, and operated in a torque-to balance mode as shown in the block diagram in Fig. 1.

Test Equipment Requirements

a) In the ramp mode the float shall be driven at a rate of 10MV/minute ± 3MV/minute with a linearity of 1% over a voltage range from -50 ±2MV to 0 MV and from 0 MV to +50 ±2MV.

b) the tumbling loop time constant shall be less than 10 sec. this shall be verified by manually driving the float to 50 MV and determining the time for the float to return to 18 MV after the loop is closed.

I. OA Vertical Freedom Test

The gyro shall be positioned OA Vertical up, IA East and shall be normally excited except wheel off. The preamp gain shall be set at $10 \frac{MV}{MV}$.

a) The ramp shall cause signal e_1 to vary according to the schedule in Fig. 2. The float torque shall be continuously recorded throughout the forty-six minutes of testing. This will result in a torque trace which is shown idealized in Fig. 2. The tape speed shall be approximately 0.4 in./min.

b) Best straight Lines, L, shall be drawn through the steady-state portions of the torque trace. These lines are defined by the average torque levels at 2 and 8 minutes after the beginning of each float rotation. The averaging shall be done over a 30 second interval about these times (Refer to Fig. 2).

c) Measure the slope of the Best Straight Line for the first direction of float rotation. This Elastic Restraint slope is shown in Fig. 2 and shall not exceed the limit specified in PS 2021500 paragraph 3.2.3.2.

d) Observe all spikes and deviations from the Best Straight Line. The deviation shall not exceed the limits specified in PS 2021500 paragraph 3.2.3.2.

II. IA Vertical Freedom Test

The gyro shall be positioned IA Vertical up, OA South, and shall be normally excited except wheel off.

Repeat I a, b, and d adhering to the same requirements.

NOTE: It is advisable to measure each of the four suspension voltages at some time during the first direction of float rotation in both the OA Vertical and IA Vertical gyro orientations. These voltage levels can be compared with the suspension voltages measured during prolonged deviations on the torque trace. This comparison can be used to distinguish problems due to fluid contamination from those involving pivot-and-jewel clearance, end shake, etc.

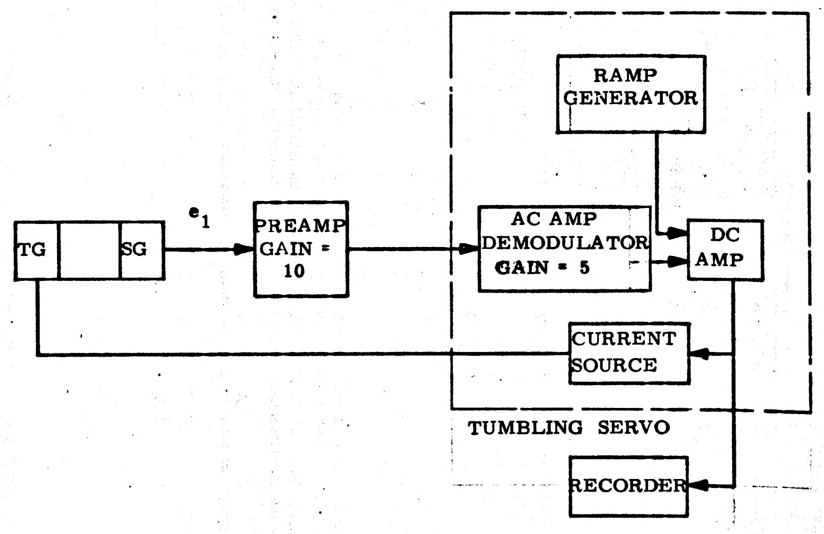

FIG I TORQUE-TO-BALANCE RAMP MODE BLOCK DIAGRAM

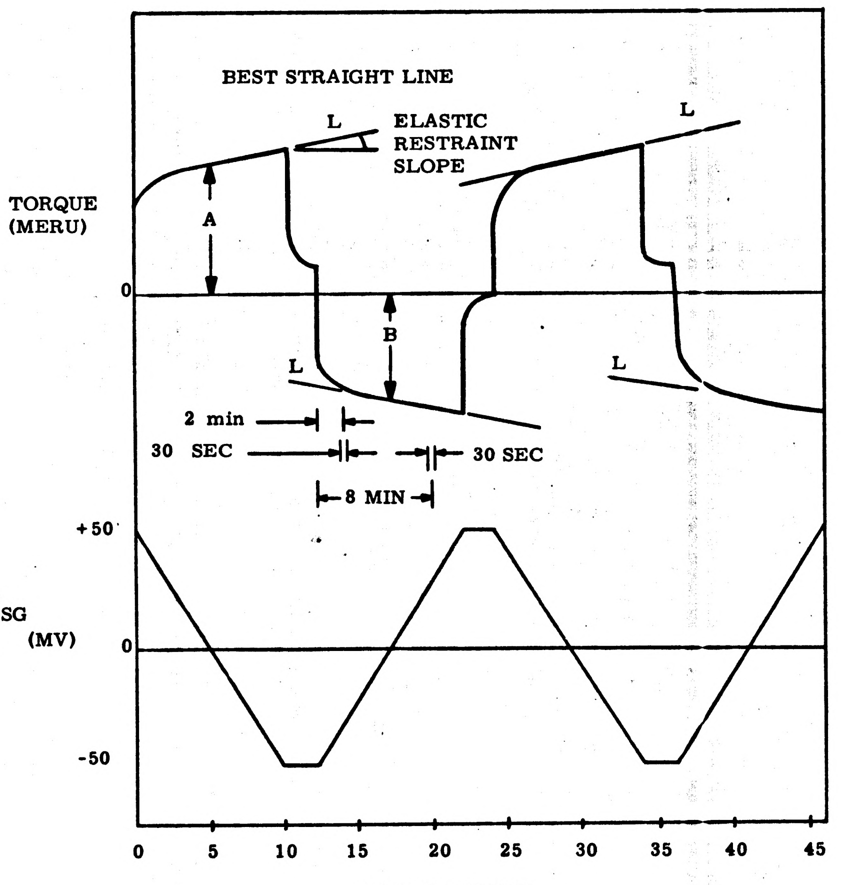

FIG 2 CONTINUOUS FLOAT ROTATION SCHEDULE

APOLLO II IRIG Specification
MC 25-859
Release Date Nov. 25, 1964
Release Revision A
Class A **Release**
TDRR 14531

Procedure for Testing
SG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	 NASA
2/12/65	B	16568	1, 2	WK	2/17/65
3/18/65	C	17645	1, 2	WK	WJR
6/8/65	D	20017	1	WK.	

TP#11938

This MC specification consists of page i ___ and 1 to 2 inclusive.

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PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

MC 25-859

SHEET 1 OF 2

Rev. A 11/9/64 Rev. B 2/12/65 Rev. C 3/18/65 Rev D 6/3/65

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5%F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Figure 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

DB 2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1° and I_m = 43.5 ± 3 ma.

A B 2.5 Disable SG primary and measure suspension reaction torque. Record. Limit is 0 ± 0.15 dyne-cm.

3.0 Signal Generator

B 3.1 Reconnect per Fig. 1. Disable suspension, and increase V_{in} to 4.0 v.

A 3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating and recording the angular sensitivity and relative phase of E_o vs V_{in}.

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DATE: February 25, 1964

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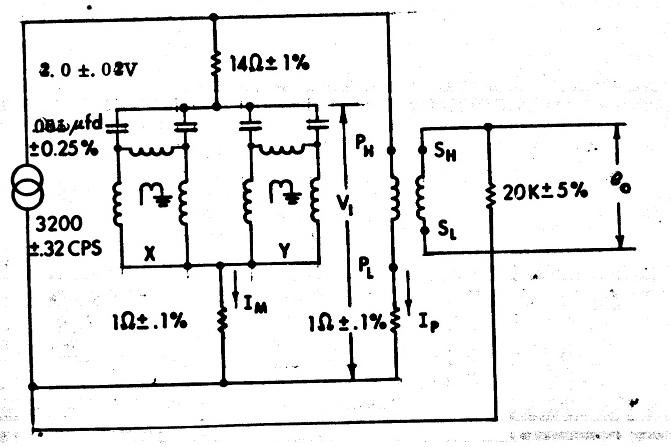
SHEET 2 OF 2

3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.

A
B
C



No connections shall be made to quadrature or center tap tap terminals.

Fig. 1

APOLLO II IRIG Specification
MC 25-880 REV E
Release Date 8 FEB 68
Release Revision —
Class A Release
TDRR 35585

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
8 FEB 68	—	35585	INITIAL RELEASE	R/Booth 2-7-68	—
8/1/68	A	36624	All, except 8, 20, 24.	B Rockower 9-17-68	—
1/21/69	B	37228	20	MGM EA	WLS
1/31/69	C	37287	10	MGM EA	WLS
2/21/69	D	37379	19, 20	EA	RJJ
8/28/69	E	37773	1, 7, 8, 9, 12, 15 17, 18, 19, 23	EA	MDH

This MC specification consists of page i to___and 1 to 24 inclusive.

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MC 25-880 REV E

APOLLO II WHEEL PROCEDURE

INTRODUCTION: This specification outlines in detail the Apollo II wheel assembly procedure. Figure 1 may be referred to as an outline guide for this procedure.

1.0 BEARING MEASUREMENT

1.1 Bearings are to be received in the disassembled state with a set of outer races, shaft and matching balls sealed in one package, and oiled with Teresso V-79 oil to prevent rust. The retainer (C-2021816) shall be packaged separately and shipped dry.

1.2 Clean the outer races, balls, and shaft per (MC 25-878) and inspect the bearing surfaces. No defects will be accepted on balls and critical areas of inner and outer races as defined by fig. 1 (MC 25-887) (e.g., corrosion, brinelling, burrs, stains, gage marks, raised metal, tears, cuts, scratches, stringers, nicks, dents, digs, gouges, comets, pits, and inclusions). Check for oil wettability per (MC 25-890).

1.3 Set up the precisionaire column and air rings. Check the sensitivity and then make at least 4 measurements of the O.D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurement. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O.D. measurements are made and record this information together with the average O.D. measurement on (MC 25-886). Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Set up the precisionaire column and air ring to measure the shaft 0.180000 diameter following the procedure outlined above.

1.4 Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O.D. or the shaft 0.180000 diameter. Check contact angle per Para 7.

1.5 Reclean the outer race per (MC 25-878) as above. Dip the outer races and shaft in V-79 oil and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adapter. The oil should be Teresso V-79 which has been taken from a bottle filled after oil filtration. The oil shall be discarded after a two month use period.

1.6 Seal the bearings in clean plastic bags. Replace in original outer package and store until ready to use.

1.7 Identify the outer package with a number and record the diameters of the bearing races and shaft and the temperature at which they were measured on the outside of the bearing package.

1.8 Equipment

Ultrasonic Cleaner
Plastic Bags
Quick Seal type 150 Natl. Inst. Co., Baltimore, Maryland
Master Gage Plugs, Class XXX (.180000-.180020)
Sheffield Air Ring with two small jets for measuring the (.180000-.180030) diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring (.3748-.3749) diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749, .3750, .3751)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2.0 INERTIA ELEMENT ASSEMBLY

2.1 Check inspection report on wheel hub, hysteresis ring and inertia rims.

2.2 Clean hysteresis rings 3 minutes in varsol and 3 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution.

2.3 Clean inertia rims and wheel hubs in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 minutes each time. Vacuum dry after each solution.

2.4 Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (MC, 25-886).

2.5 Place one inertia rim (O.D. chamfered end down) and the hysteresis ring in fixture(B-87392).

2.6 Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F, immerse wheel hub into liquid nitrogen, until temperature stabilization takes places.

2.7 With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

2.8 Let wheel hub slide over this post by its own weight.

2.9 Remove this assembly from fixture, and insert the second inertia rim (O.D. chamfered end down) into fixture and repeat steps 2.6 through 2.8.

2.10 Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve(A-87392.5) and an arbor press by pressing against the sleeve while rotating fixture.

2.11 NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture (B-87392)
Depth micrometer
Hot plate
Tweezers
Drake Arbor Press
Simpson Model 388 thermocouple indicator or equivalent.

3.0 TEMPERATURE CYCLING

3.1 Place in a suitable closed glass containerum foil.

3.2 Place in the cycling container, (2A3-10B177) Evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi. Seal off container and put in temperature cycling chamber.

3.3 Cycle the wheel assembly four times between -60°F and + 200°F.

Equipment

Cycling container (2A3-10B177)
Tenney Test Chamber
Reynolds Aluminum Foil

4.0 LAPPING BEARING BORES

NOTE: Insure that all finished 0-80 tapped holes of hub element have been lapped.

4.1 Measure the lapping room temperature and, using the wheel assembly data

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PREPARED BY: Edward J. Hall
DATE: August 15, 1957
M.C. #810
SHEET 1
OF 2

Motor Stator Processing

Stator No. S-______________ MT________, ________Pole

Type of Potting Compound used ______________________________

Weight of Core ______________________________

Weight before potting ______________________________

Weight after potting ______________________________

Weight after finish I.D. grind ______________________________

Remarks:

Rev. D 2/7/61 Revised and retyped Rev. E 9/1/64

SIMPSON READINGS (OHMS)

Measuring Points	Before Forming	After Forming	After Potting	After Initial Grind	After Mounting in Gimbal	After Final Grind	After Complete Wiring & De-gassing
Date							
250V HiPot	X	X					Phase A only
A+ to A-							
B+ to B-							

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M.C. #810
SHEET 2
OF 2

1. Initial cure time 40 hours at 300°F under vacuum. ( )
2. Cycling Procedure (Max. rate of temperature change not over 3°/min.)
   - a. Room temp. to +200°F; hold 15 min. (cycle twice) ( )
   - b. Room temp. to -60°F; hold 15 min. (cycle twice) ( )
   - c. Room temp. to +200°F; hold 15 min. (cycle once) ( )

   E Alternate Cycle: Cycle from -65°F three times at a maximum rate of 4°/min.
3. Inspect for cracks.
4. Resistance Check (Ohmmeter): Continuity ( )
   Grounds ( )
   Record on Page 1 ( )
5. Hi-Pot Check at 250 volts (Record on Page 1) ( )
6. Repeat Step 4: Continuity ( )
   Grounds ( )
   Record on Page 1 ( )
7. Remarks:

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sheet (MC 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator or Cleveland Indiron should not exceed 20 microinches, and should not extend more than .050" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (MC 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150° ± 5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
  Model 153-40 used with small jet spindles and Class XXX
  Master Gage Rings
Hand Lap-3/8" dia. x 3" long-American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Co., Inc.
Zeiss Stereo Microscope or American Optical
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner
Cleveland Indiron

5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries inc.,
  Sycamore, Illinois

6.0 'B' DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.976000 gage block and the Johansson Mikrokator S 510- E-8, measure accurately (to within 5 microinches) dimension 'B' and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment

C.E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per (MC 25-878).

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used. Insure that interference is reduced to a minimum by predenting the ball pockets. This should eliminate possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

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measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture (D-95850). Rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\cos \beta = \frac{E}{d} \left[1 - 2 \frac{N_e}{N_i} \right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on (MC 25-886.)

Equipment
Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension "A" as recorded on bearing package by manufacturer, and dimension "B" as measured in section 6, determine spacer thickness by using the following formula:

A = B + t-65 microinches
or t = A - B + 65 microinches

where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 20 microns minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE
9.2.1 Centrifuge retainer for 15 ±1 minutes at 9000 ± 150 G's one side only.
9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.
9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 20 microns minimum.
9.2.4 Remove retainers from oven and weigh immediately.
9.2.5 Compute oil retention of each retainer as follows:

$$\% \text{ retention} = \frac{W_1 - W_o}{W_0} \times 100$$

where W_0 = weight of dry retainer

W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.
If oil retention is outside specified retention range, retainers may be re-soaked in oil and/or recentrifuged varying the times to achieve the specified retention limits.

9.2.6 After retainers are impregnated, O.D. of retainer, pocket diameter and, pocket alignment shall meet tolerances shown on (Dwg. C-2021817).

9.2.7 Store retainers in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

9.2.8 General Notes:

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9.2.8.1 Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

9.2.8.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.7 above.

9.2.8.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

10.0 SYNTHANE RETAINER PROCESSING

10.1 Synthane Retainer Impregnation

10.1.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ±5°F and 29.5 inches Hg vacuum minimum for five hours minimum.

10.1.2 Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

10.1.3 Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150° ±5°F and 20 microns minimum, outgas the retainers and oil until bubbling stops.

10.1.4 Immerse retainers in oil and hold for an additional two hours minimum or until all bubbling ceases.

10.1.5 Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

10.1.6 Remove retainers and oil from oven and allow retainers to remain in oil for two hours minimum.

10.2 Synthane Retainer Impregnation (Alternate)

10.2.1 Clean retainers in ultrasonic cleaner for 3 to 4 minutes in varsol followed by 3 to 4 minutes in freon. Assign numbers to retainers and place them in vacuum oven at 150° ±5°F and 29.5 inches Hg vacuum minimum for 18 hours minimum.

10.2.2 Complete retainer impregnation procedure as outlined in paragraphs 10.1.2 to 10.1.6, above.

10.3 Synthane Retainer Centrifuge

10.3.1 Centrifuge retainers for twenty minutes at 4000 g's as follows:

10.3.1.1 Install retainers in container assemblies (2A3-10A187-1) or equivalent always keeping track of the assigned numbers. Place these assemblies in oven. Heat assemblies to 150° ±5°F allowing 15-20 minutes for temperature to stabilize.

10.3.1.2 Remove from oven and install assemblies into centrifuge plate (2A3-10C187-1), or equivalent, and spin for 10 minutes ±1/2 minute at 4000±100 g's (6140 rpm ref.)

10.3.1.3 Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps in paragraphs 10.3.1.1 and 10.3.1.2 above.

10.3.1.4 Remove from centrifuge and blot retainer edges with lens paper. Place retainers in oven at 150° ±5°F for 3 to 6 hours.

10.3.1.5 Remove retainers one at a time from oven, reweigh, and compute percentage (%) absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking

W_2 = weight of retainer after centrifuging

Acceptable oil absorption values are in the range of 2 to 5%.

10.3.1.6 After recording weight and percentage retention, place in a clean glass container using desiccants to minimize the humidity of the storage environment.

10.4 Equipment

10.4.1 International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

11.0 FINAL CLEANING

11.1 Examine bearing retainers very carefully under a 25X to 30X microscope to insure no foreign material is present on the retainer surfaces and ball pockets. A needle and magnet can be used to remove foreign particles.

11.2 Clean all bearing assembly parts, except retainers, per (MC 25-878.)

11.3 Clean wheel inertial element 3 to 4 minutes in varsol and 3 to 4 minutes in freon in ultrasonic cleaner. Vacuum dry after each solution. Heat wheel inertia element in oven at 150 ±5°F and evacuate for one hour minimum at 29.5"Hg vacuum maximum. Examine under a 25X to 30X microscope. Clean spacer, caps and screws in 2 separate solutions of trichloroethylene in ultrasonic cleaner, 3 to 4 minutes each time. Vacuum dry after each solution.

12.0 OUTER RACE ASSEMBLY

Prior to assembly, the balls may be prelubricated as follows:

Mix 500 parts of Freon to 1 part of oil in a beaker and immerse the balls.
Vacuum dry the balls and examine them under a 25X - 30X microscope making sure that the balls are clean.

Assemble retainers, balls and outer races as follows:

12.1 With fixture (A-118577) assembled, place outer race with stamped end up on shoulder of fixture (A-118579).

12.2 Place retainer inside, outer race, then carefully lay balls on .062 radius of fixture (A-118578).

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12.3 With bone tweezers wiggle outer race carefully to allow balls to be guided into pockets of retainer. Inspect carefully with 25x to 30x microscope for contaminants.

12.4 Assemble the second bearing by repeating steps 12.1, 12.2 and 12.3.

12.5 Equipment

12.5.1 Fixture Assy (A-118577)

12.5.1.1 Fixture (A-118579)

12.5.1.2 Fixture (A-118578)

12.5.2 Bone Tweezers

13.0 BEARING INSTALLATION

13.1 Place the inertia element assembly on the holding fixture (A-88948.3) with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

13.2 Lay the bearing marked II on the bore and with bone tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

13.3 Place a spacer (C-2021670) over the bearing and use fixtures (A-88948.1) and (A-88948.2) to press into the bore. The force necessary to push the bearing into the bore will be in the range of 2-5 pounds (reference).

13.4 Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step 13.3 above press bearing into its final position.

13.5 Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight. NOTE: Insure that all threads of 0-80 have been lapped prior to assembly.

13.6 Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

13.7 Place corresponding end of shaft upward on shaft holding fixture assy (Dwg. 166042). Hold element with installed bearing and install on shaft. Using wheel holding fixture (Dwg. 166045) install on top of element. Invert entire fixture ass'y so that wheel holding fixture (Dwg. 166045) becomes the base and carefully remove shaft holding fixture (Dwg. 166042).

13.8 Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

13.9 Repeat Step 13.2 above for bearing number 1.

13.10 Select a spacer 0.0005" thicker than the calculated size and use fixture (A-88948.1) and (A-88948.2) to press the bearing into the bore. (The use of a thicker spacer is suggested to prevent brinelling of the bearing in case of error in measurements.)

13.11 Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

13.12 Install beryllium cap and insert four 0-80 Allen head screws .187 long.

NOTE: Insure that all threads of 0-80 Allen head screws have been lapped to remove burrs and smooth down rough edges. Assemble protective cap (Dwg. 166037) before using Allen wrench to adjust 0-80 screws.

Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum without placing any preload on the bearings.

13.13 Inspect with microscope at 30X heads only of 0-80 screws for loose particles of metal.

13.14 Remove dust protector if necessary prior to shaft strain.

14. SHAFT STRAIN

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary. The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

14.1 Insert a 52100 steel rod (.093 diameter) into the .101 shaft I.D.

14.2 Assemble top adapter (A-92246.1) to the #2 end with the flat end inward and tighten to a torque of 0.75 in.lb (strain gage measurements at MIT indicate that 0.75 in.lb of torque produces 76 microinches/inch shaft strain and a corresponding 65 microinches shaft deformation). The 65 microinches shaft deformation will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adapters and shaft will not be removed until that time.

15 FINAL SPACER SELECTION (Preload Fixture D-92272)

15.1 Assemble shaft adapter (A-92278) to the #2 end of wheel.

15.2 Assemble shaft cap (A-92277) to the #1 end of wheel. In assembly of these adapters care should be taken so that the applied torque does not exceed 0.75 in.lb.

15.3 Preheat wheel in oven at 150° ± 5° for 15 to 20 minutes. Remove wheel from oven and hand rotate shaft in one direction a sufficient number of times to prelubricate raceways and balls. Check for oil film on balls and inner race. If oil film is not present reheat wheel for an additional 25-30 minutes and repeat prelubrication procedure. Once prelubrication is achieved, inspect bearings for contamination and repeat step 13.13

15.4 Allow wheel to return to room temperature and position wheel on top plate (C-94190). Assemble weight pan (A-92281) with a 1 lb. weight.

15.5 Carefully inspect clamping ring (C-94185) on top of wheel insuring that delrin washer (A-94186) contacts wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

15.6 Attach weight pan (A-92281) to chain hanging from shaft adapter (A-92278).

15.7 Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying a three pound load. Lift the weight, zero the meter, and then gently apply the three pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

Note: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

15.8 Remove Mikrokator tip from wheel hub. Ensure that the 0-80 Allen head screws are not tightened sufficiently to apply preload to the bearings.

15.9 Place Mikrokator tip on the high point of shaft cap (A-92277). Maximum run- axial runout of shaft cap is 10 microinches with ±45° rotation.

15.10 Apply three pounds axial load and record the Mikrokator meter reading. This is the reference to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point.

Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

15.11 Using the Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation care should be taken to insure that no part of the apparatus is disturbed.

15.12 Rotate the bearing shaft approximately ±45° several times before recording the Mikrokator deflection. If the difference between this measurement and the reference established in (15.10) is within ±10 microinches the proper preload has been achieved. If not, change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference. Repeat the above procedure starting with paragraph 15.4.

15.13 Measure axial compliance by hanging two, three, and four pound weights on the shaft end and record the displacement of the indicator from zero for each weight in (MC-811). These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound Record axial compliance on (MC-811).

15.14 Before preliminary dynamic balancing, position of cap, (Dwg. C-2021669), shall be checked with cap centering ring (A-92244). Remove socket head screws on number one end of wheel and replace with final 0-80 screws.* Inspect at 25x to 30x for possible contamination of bearings. If necessary the cap should be repositioned so as to be concentric with wheel hub neck.

16 DYNAMIC BALANCING (Preliminary)

NOTE: Balancing may be performed after temperature cycle (17).

16.1 Attach thermocouple wire with calibrated Alnor meter to center of OD of stator housing.

*NOTE: All threads of 0-80 screws shall have been previously lapped.

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Cover stator housing and entire rotor platform with heater blanket of of chromalox 630-2, 115 volts, 25 watts (R62) or equivalent. Place wheel in oven to preheat for approximately 30 minutes minimum at 150°F and at the same time preheat the rotor platform until Alnor meter indicates 140°-145°F. Remove wheel from oven and place in dynamic balancer. Increase the gain on amplifier until wheel just starts to rotate, note the voltage, and back off immediately. This is the breakaway voltage. NOTE: If breakaway voltage exceeds 16.5 volts check for retainer rub, high preload, etc. Increase amplifier gain to 28 volts. The wheel will rotate at synchronous speed and temperature will increase. At this speed the rotor platform temperature should be reset to 140°-145°F as indicated by Alnor meter.

16.2 Dynamically balance the wheel until the residual unbalance is no greater than 0.10 dyne-cm at 12,000 rpm. Corrections shall be made by filing O.D. of the inertia rims with correction planes as far apart as possible. Prior to making balance corrections, both ends of the wheel must be carefully sealed off with delrin caps, Dwg. No. B-166037 to protect the bearings.

16.3 Examine the areas of the wheel and bearing shaft under a microscope after each increment of balance. Visually inspect under 25x to 30x for contamination or physical change in bearings. Remove any trace of contamination. Before removing cups, clean the wheel thoroughly with suction hose.

16.4 Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment
Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06)
Alnor Meter

17 TEMPERATURE CYCLING (Bearings Installed)

17.1 Place in a suitable closed glass container and place in the cycling container, 2A3-10B177.

17.2 Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.

Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere.

17.3 Cycle the wheel assembly four times between +40°F and 180°F.

Alt. Cycle: 32°F to 180°F

Equipment
Cycling Container: Tenney Test Chamber or Equivalent
Vacuum Pump

18 REFER TO MC 25-881 FOR DYNAMOMETER TESTING

19 SEALING CAP SCREWS

19.1 Remove wheel from the dynamometer and place it in stand (A-88948.3). Remove cap holding screws one at a time, and with a very small drop of Loctite, touch the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace each screw and fasten with 11 to 13 oz. in. of torque. Care

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should be taken to prevent metal damage on slot of screw head.

NOTE: LCA-4 adhesive with BA-5 activator (SCD 2021552) per (MC 25-304) may be used as an alternative material to tack screw heads.

19.2 With a microscope examine the area around the screw head and wipe off any excess Loctite. (Loctite will not cure if exposed to air). Repeat this procedure to all 8 screws.

19.3 To speed up Loctite cure place in a suitable closed glass container and place in oven for one hour at 150°F.

Equipment
1) Fixtures (A-88948.3), (A-92244)
2) Bone Tweezers
3) Jeweler's screw driver.
4) Loctite sealant type A
American Sealants Co., Hartford 11, Connecticut.
5) LCA-4 per (SCD 2021552)

20 DYNAMIC BALANCING (Final)

20.1 Place the wheel in oven to preheat for 30 minutes minimum at 150°F. Remove wheel from oven and place in dynamic balancer. With amplifier gain adjusted to 28 volts, check the final balance of the wheel and make necessary corrections to achieve maximum residual unbalance of 0.10 dyne-cm at 24,000 rpm.

NOTE: This check should be made with the wheel at operating temperature as follows: The procedure outlined below shall be followed to bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O.D. of stator housing.
2) Cover the stator housing and entire rotor platform with heater blanket chromalox 630-2, 115 volts, 25 watts, (R62) or equivalent.
3) Run the wheel at synchronous speed until the Alnor meter indicates 140° - 145°F.

Equipment
Micro Dynamic Balancer, Model K-1
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
Alt: Schenk Balancer Model #R-06

21 FINAL INSPECTION

21.1 Place wheel under 30X microscope and inspect for lint and dust particles. Examine both bearings for any evidence of incipient varnish build-up on either retainer ball

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pocket or raceways. Any evidence of varnish is cause for rejection of the wheel assembly.

21.2 Clean off with vacuum hose and repeat 21.1.

21.3 Record final weight of wheel on (MC-811) (MC 25-628) and (MC 25-605).

Equipment
Zeiss Stereo Microscope, or equivalent
Vacuum hose, or equivalent

21.4 Place the wheel in a covered glass container and store in moisture free atmosphere.

22 INSTALLATION IN FLOAT

Install the wheel into the float according to the Float Assembly Procedure (MC 25-855) A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

22.1 Assemble adapter (A-95721), firmly to the VS-10.

22.2 Thread lock-nut (A-92357) to the 12-72 stud until it bottoms.

22.3 Assemble the (-) SRA end of the float to adapter (A-95721) very carefully until it bottoms, then back the float off one full turn.

22.4 Fasten the float by bottoming lock-nut (A-92357) firmly against the bushing, using spanner wrench (A-92359).

22.5 Set variable frequency oscillator (Fig. 2) at 1500 cps and adjust oscillator gain so that the acceleration of the float is less than 2 g's.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

22.6 Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V.T.V.M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat this step 3 times and take the average of the resonant frequencies.

22.7 Using this resonant frequency and curve (Fig. 3) determine the axial compliance of the wheel.

22.8 This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on (M.C. 811) within ±0.25 microinch/lb.

22.9 If the axial compliance as determined in step 22.7 above is higher than the compliance recorded on(MC 2-811) insert wrench (A-92262)in the + SRA bushing and lock wrench firmly by turning locking screw.

22.10 Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel was installed in the float). Remove wrench (A-92262), and repeat steps 22.6 and 22.7. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step 22.7 is lower than that recorded on(MC-811) insert wrench (A-92262), and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps 22.6 and 22.7. It is suggested that the torque values be increased in increments of one inch-lb at a time until the required compliance is achieved.

22.11 With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps 22.3 and 22.4.

22.12 Determine the radial compliance repeating steps 22.6 and 22.7.

22.13 Record both axial and radial compliances in(M.C. 25-605)

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 3.0 microinch/lb. If the term ΔC is greater than 3.0 microinch/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4° / min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in(MC 2-811). If the compliance is outside the imposed limits, the float should be retorqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

22.14 Using a spade oiler, or other suitable tool, apply LCA-9, (SCD 2021529) (MC 25-302) to the -SRA bushing and torque to 5 inch pounds.

22.15 Remove the +SRA bushing and repeat the cementing operation per step 22.14. Replace the +SRA bushing and torque to 3 inch pounds.

22.16 Repeat step 22.1 through 22.13 as necessary to reset compliance. (Note: the torque required at this time may be higher than the initial torque).

22.17 Cure assembly for 2 hours at 180°F maximum.

22.18 Recheck compliance after cure and record on(MC 25-605)

22.19 Refer to(MC 25-855)for float sealing, helium filling and leak check.

23. FINAL RUN-IN

23.1 Insert the thermistor holder (2A3-10A180-1.2) with the Fenwal Thermistor probe, into one of the IA balance ports.

23.2 Install the float into fixture (C-87364) and attach power and thermistor leads onto provided terminal strip.

23.3 Install top plate (A-87364.1)on top of the float.

23.4 Turn heater on and set the Fenwal indicator at 135°-140°F. With wheel at 135°-140°F turn on power supply. After wheel is operating for 15-20 minutes, reset Fenwal indicator to 137°F.

23.5 Perform the wheel in float evaluation per(MC 25-882)

24. DELIVERY

Continue float assembly per(MC 25-855)

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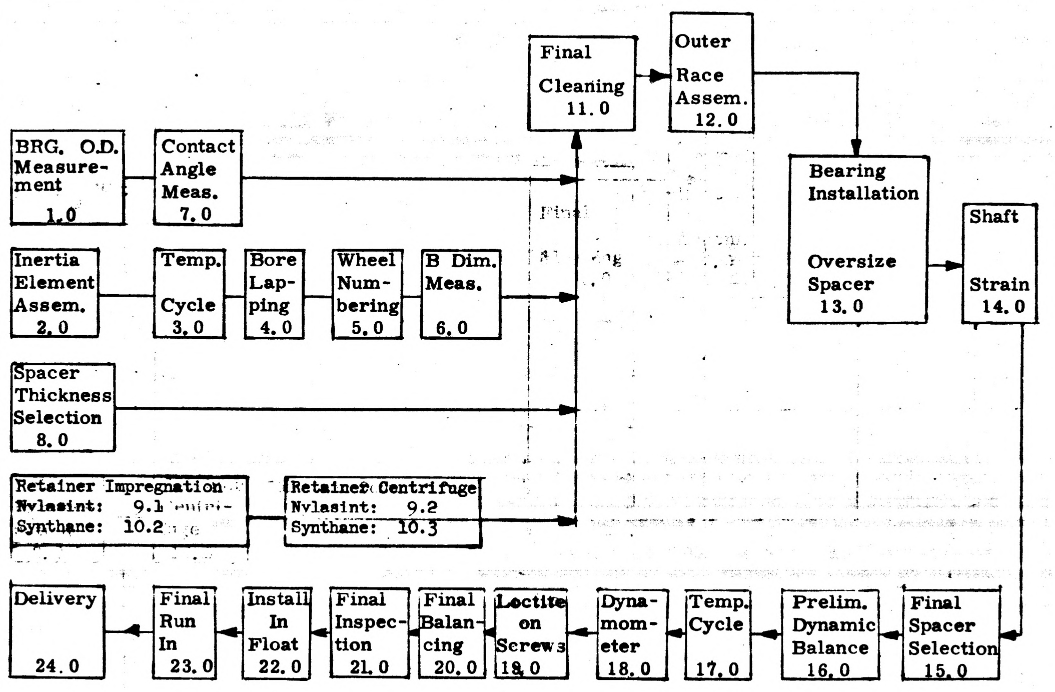
BRG. O.D. Measurement 1.0
Contact Angle Meas. 7.0
Inertia Element Assem. 2.0
Temp. Cycle 3.0
Bore Lapping 4.0
Wheel Numbering 5.0
B Dim. Meas. 6.0
Spacer Thickness Selection 8.0
Retainer Impregnation Nvlasint: 9.1 Synthane: 10.2
Retainer Centrifuge Nvlasint: 9.2 Synthane: 10.3
Final Cleaning 11.0
Outer Race Assem. 12.0
Bearing Installation Oversize Spacer 13.0
Shaft Strain 14.0
Final Spacer Selection 15.0
Prelim. Dynamic Balance 16.0
Temp. Cycle 17.0
Dynamometer 18.0
Loctite on Screws 19.0
Final Balancing 20.0
Final Inspection 21.0
Install In Float 22.0
Final Run In 23.0
Delivery 24.0

Wheel Assembly Procedure Flow Diagram

Fig. 1

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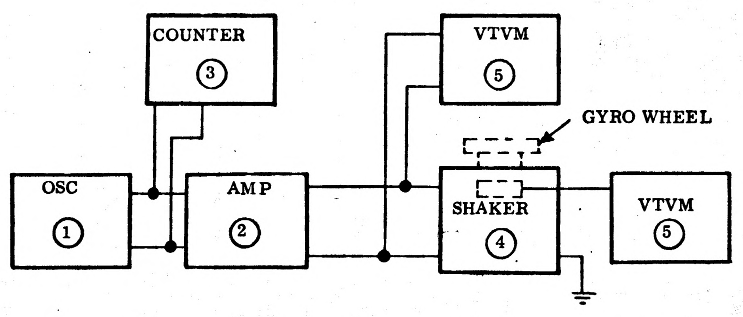
OF 24

Compliance Checking Equipment

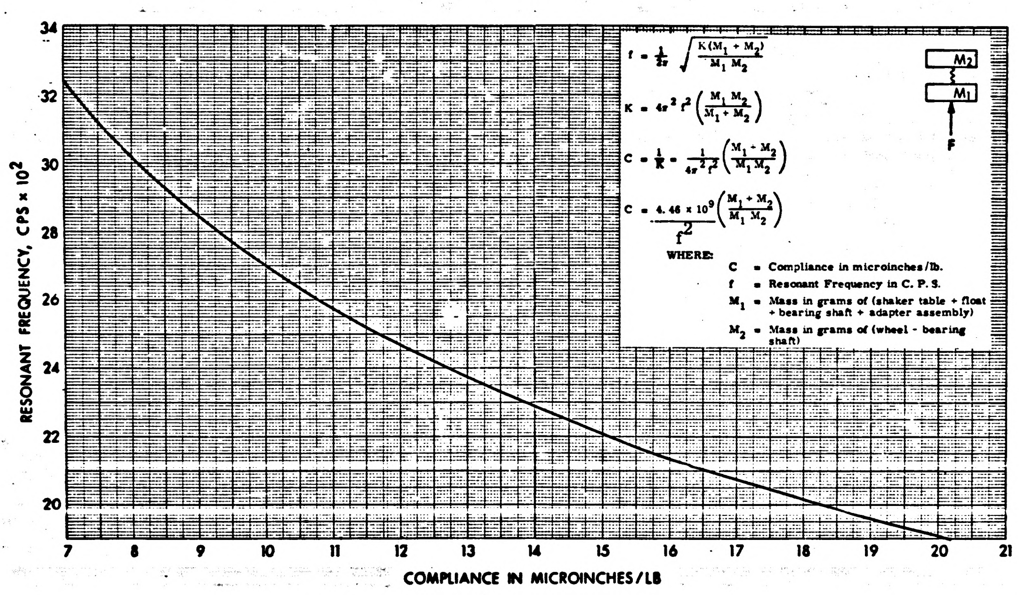
Apollo 2 Gyro


COUNTER
3
VTVM
5
GYRO WHEEL
OSC
1
AMP
2
SHAKER
4
VTVM
5

1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V.T.V.M. - Hewlett Packard Model 400H

FIGURE 2

IL 27



$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.

f = Resonant Frequency in C. P. S.

M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)

M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

FIG 3

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CAMBRIDGE, MASS.

PREPARED BY: H. Vernon
DATE: February 14, 1964
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OF 1

APOLLO II RADIAL CENTERING TEST

1. Remove the S. G. and T. G. primary excitation.
2. Replace the 9.1 ohm swamping resistor with a 50 ohm resistor.
3. Increase each of the eight working capacitors in equal increments until the suspension currents lag their respective suspension voltages (low side of 50 ohm resistor to ground) by 70 ± 2°. The phase angle measurement is to be made after adjusting the supply voltage to give suspension currents of 50 ± 5 ma.
4. Allow the suspension to reach a position of force equilibrium (axial and radial), and record the magnitude and phase of the radial rest positions.

   Sx = ; Sy = ; Tx = ; Ty =

   NOTE: Satisfactory axial equilibrium is achieved when the suspension currents are equal within 5%.
5. Short, simultaneously, the appropriate capacitors to rotate the float to diagonally opposite stops.

   Example: Short capacitors S. G. 1-8 and T. G. 6-7.
6. (a) Ensure that the float has reached its radial stops -- when the radial output voltages of the shorted axes, as indicated on a VTVM, show no change for a period of one minute.

   (b) Remove one short and read the initial radial voltage and note its phase.

   (c) Replace the short and record the data.

   (d) Repeat step (6b) for the remaining capacitor and record.
7. Move the shorting bars to the opposite ends of the above axes:

   SG 4-5 and T. G. 2-3 and repeat steps (6a through 6d).
8. Continue shorting the remaining capacitors in pairs and record each radial voltage and phase.
9. Use the data from steps 6 through 8 in conjunction with the radial rest positions from (4) to determine the centering ratio of each axis.

TDRR 14363 NOV 18 1964

APOLLO II IRIG Specification
MC 25-852E
Release Date Jan. 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
5/7/65	B	18998	1, 3		WJR
7/5/68	C	36502	All		
12/9/68	D	37098	2	MGM EA	RJJ
4/21/69	E	37525	Was 6 pages, All now 7 pgs	MGM EA	WLS

TP#11938

This MC specification consists of page i to ___ and 1 to 7 inclusive.

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PREPARED BY: C. J. Cormier
DATE: 4 April, 1968
MC 25-852 E
SHEET 1 OF 7

ASSEMBLY OF SHROUD TO GYRO UNIT, APOLLO II

SHROUD END COVER ASSEMBLY

Equipment and Materials Required

450 Watt Hot Plate
50 Watt Soldering Iron Pyramid Tip
Variac
Solder - Sn 96 Ws
Solder - Sn 60 Ws
Flux -Kester 891- Kester 1571
Artist Brush #3 - Acid brushes
Trichloroethylene
Freon
Ajax, Powdered Boraxo
305A and 38-1200 lapping Compound
#00 and medium grit polishing paper

1.0 End Cover Preparation

A. Rough up the areas to be tinned on all the shroud parts, using a medium grit polishing paper, steel wool or equivalent.

B. Clean all the parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, follow by an ultrasonic rinse in clean freon for the same time period.

C. Leak check the end covers for porosity using fixture: 2A3-10B182.0 (Optional)

2.0 Tinning Procedure

A. Place the end cover on hot plate and heat to 250°F ± 10°.

B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.

C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.

D. Repeat steps B and C on inside of cover.

E. Remove from hot plate and allow to cool.

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3.0 Cleaning Procedure

A. With an acid brush scrub the end cover using clean trichloroethylene.

B. Follow by scrubbing under running hot water using Ajax, powered Boraxo or equivalent.

C. Thoroughly rinse under running hot water and dry.

4.0 Assembly of Seals to End Covers

A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux.

B. Refer to 1.0 para. "B" for cleaning procedure.

C. Place cover on hot plate and heat to 490°F± 10°

D. Tin the .125 diameter on the 16 terminal seals, 2021508, with Sn-9 [illegible]". solder and Kester 891 flux. Clean as in step 1.0 para "B".

E. Apply 1571 flux to tinned area.

F. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position.

G. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.

H. Carefully remove from the hot plate and allow to cool.

I. Repeat cleaning procedure #3.

J. Polish the end covers using 305A lapping compound, followed by 38-1200 compound. Final clean as in step #3.

K. Seal the degassing plug hole with the aluminum ball and seal screw. Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.

L. Hi Pot - 250 volts (DC).

M. Tin the 2.443 diameter on the end cover with SN-60 solder and Kester 891 flux. Clean as in step 3.0.

N. Meggar check the assembly 250 volts DC.

5.0 Main Cover Preparation

A. Tin the 2.440 diameter and two .010 deep relief with 60-40 Solder and Kester 891 flux.

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B. Refer to step #3 for cleaning.

6.0 Insert Preparation

A. Tin concave side with 60-40 solder and 891 Kester flux.

B. Refer to step #3 for cleaning.

7.0 Internal Connector Assembly

A. Check the connector assembly for shorts or opens.

B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.

C. Carefully clean all joints with trichloroethylene and artist brush, followed by a freon rinse.

D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.

E. Leak check assembly as in of step #4.

F. Apply LCA-9 adhesive (MC 25-302) over the glass seals and any exposed wires. Cure for two (2) hours minimum at 200°F ±5°.

G. Form the wires carefully at terminal to provide a 180° bend strain relief.

H. With lacing cord or shrink sleeving secure each pair of 8 wires in two places about one inch apart.

I. Make a final electrical check on assembly.

J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)

NOTE: Shrink sleeving is assembled to leads prior to soldering.

8.0 Assembly of the Shroud To Gyro Unit

A. Measure and record the bellows extension ______ in. at 135°F±5°.

APOLLO II IRIG Specification
MC 25 -882
Release Date ________
Release Revision ——
Class A Release
TDRR 35599

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		
6/21/68	A	36392	3, 11		--
8/1/68	B	36605	2, 3, 5, 10		--
11/20/68	C	37036	2		--
8/28/69	D	37771	11	EA	MDH
10/1/69	E	37850	4-11	MGM EA	MDH

TP#11938

This MC specification consists of page 1 to ____ and 1 to 11 inclusive.

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm
n = Number of run-down time checks (no less than 8)
$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.

To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic or step power variations that are greater than 20 milliwatts. The maximum variation in mean power level shall not exceed 50 mw. Figs. 1a, b, c represent acceptable power traces. 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.

The maximum allowable trace width during the monitoring period for an acceptable wheel is 40 mw. The maximum allowable variations in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11-15	20
15-20	25
20-25	30
25-30	35
30-35	40
35-40	40

2.2.2 Provisionally Acceptable Power Trace

There are two categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 Test Equipment Influences

Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.2 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig. 3i).

B. Allow the gyro to cool down and remain at room temperature during the shrouding operation.

C. Carefully inspect the OD of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

D. Align the open ports in the main cover with the +SRA and +IA gyro axis.

E. Install the end cover assembly on the unit, carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

F. Perform an electrical check for correct resistances, opens and grounds. See note below.

G. Apply a minimum amount of 1571 Kester flux to main cover-end cover joint with a piece of solder or a small artist brush.

H. With a 50 watt soldering iron (Pyramid Tip) make the joint between the main cover and end cover.

I. Excess solder can be removed with a sharp edge dental tool, and hard rubber abrasive eraser.

J. Repeat steps "E" through I for remaining end cover. See note below.

K. Clean the joints by brushing with an acid brush and clean trichloroethylene, followed by a brushing with clean freon.

L. Perform complete electrical check of unit.

NOTE: Perform measurements required in Figure 1. Record last set of measurements.

9.0 Leak Check of Shrouded Unit

A. Carefully assemble the unit to the leak check fixture, C-127683.

B. Seal off the exposed end with the aluminum ball (17S-T4) and #2-56 x 3/32" long sealing screw. Leak check this end of the unit. Maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

C. Remove seal screw and aluminum ball.

D. Repeat steps "A" through "C" for the opposite end of unit.

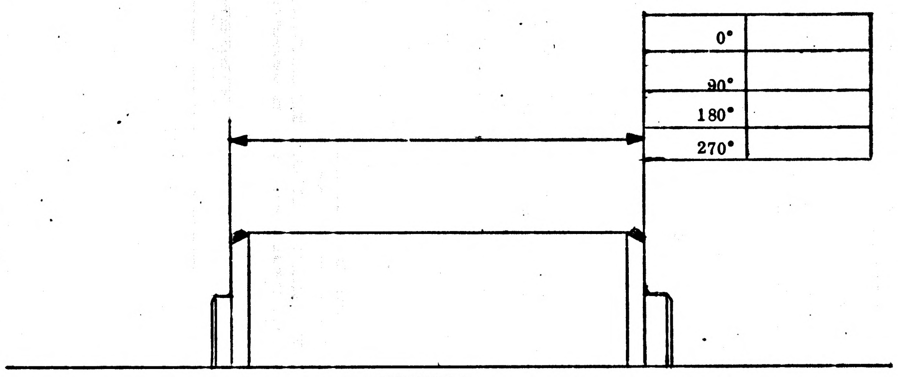


FIGURE 1

NOTE: DEGASSING SEAL SHOWN AT 0° POSITION.

10.0 Decals

A. Clean the ends of the shroud covers with a Kimwipe dampened with trichloroethylene. Remove the protective backing from the T.G. decal and fasten the decal to the T.G. shroud end cover. Aligning the IA arrow such that it is pointing toward the degassing seal. Smooth out the decal using finger pressure to eliminate ridges, air pockets, etc. Repeat the operation for the S.G. decal aligning the lettering such that it reads in a direction which is perpendicular to the degassing seal.

11.0 Preliminary Testing

A. Unit is ready for preliminary testing.

12.0 Final Shroud Sealing After Preliminary Testing

A. Cool gyro to room temperature.

B. Apply a minimum of Kester 1571 to the two (2) 0.010 inch deep reliefs on the sleeve and concave surface of the inserts.

C. Position the inserts on the sleeve so as to follow the general contour of the 2.460 diameter.

D. With a 50 watt soldering iron and Sn-60 solder, make the joint between the sleeve and inserts. Remove excess solder as before. Clean the joints with an acid brush and trichloroethylene, followed by a brushing with clean freon.

13.0 Final Leak Check of Shrouded Unit

A. With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S.S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683. Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the

---

terminals, ports and main seam at the end with helium. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

B. Remove the sealing screw and aluminum ball from the unit.

C. Invert the unit and leak check as before.

D. With the unit still on the leak check fixture and 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug. Remove the unit from the fixture and retorque both set screws to 28-30 in. oz.

E. Continue with final testing per PS 2021602 or PS 2021500, as applicable.

F. Store in a 135° ±5°F. oven awaiting delivery.

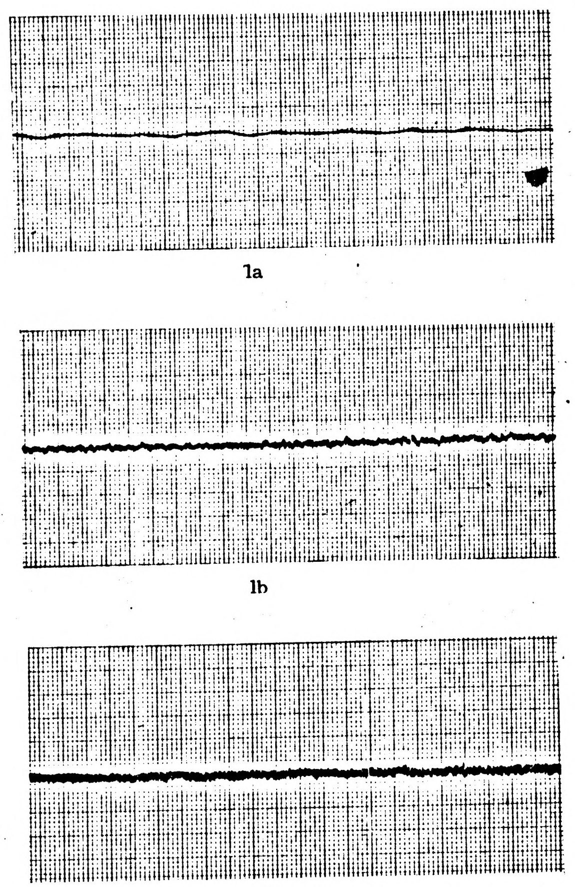


Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time Constant	1.3 sec ± 15%

Fig. 1 Acceptable Power Traces

Fig. 2a Deleted

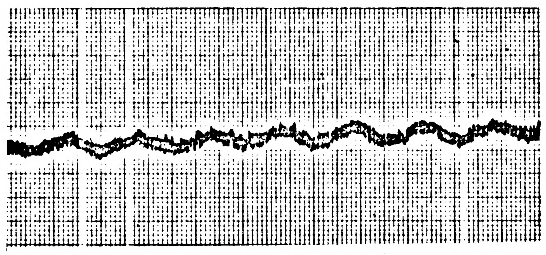
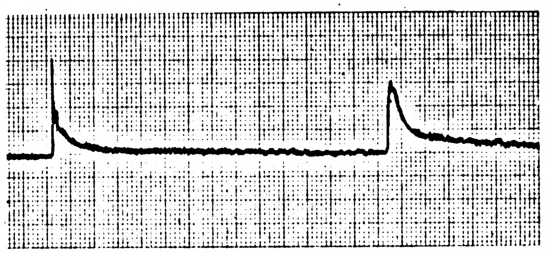

2b

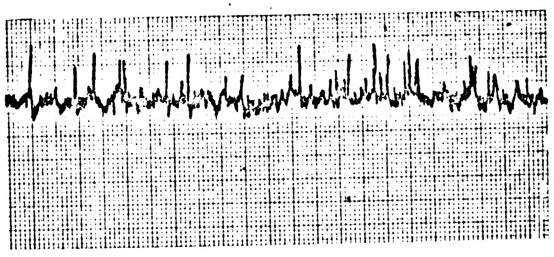
Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time Constant	1.3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

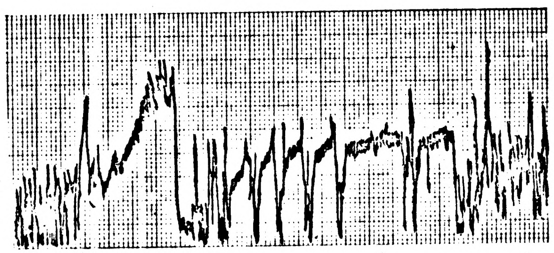
Fig. 2c Provisionally accepted power trace due to oil jog.


3a

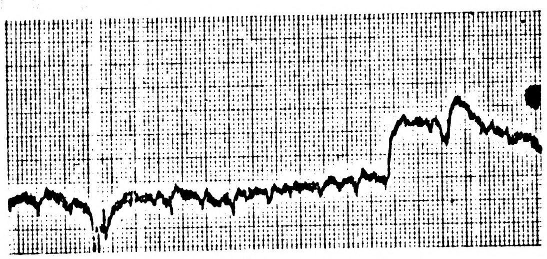
Probable Cause	
Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer superimposed on a rough and irregular power trace.

Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

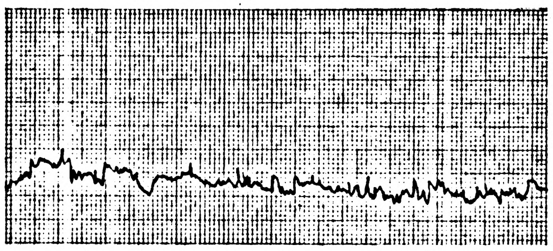
Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.


3c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces

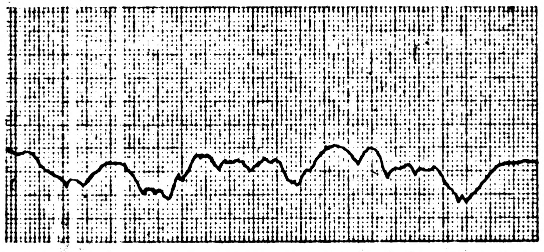


3d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced power variation.



3e

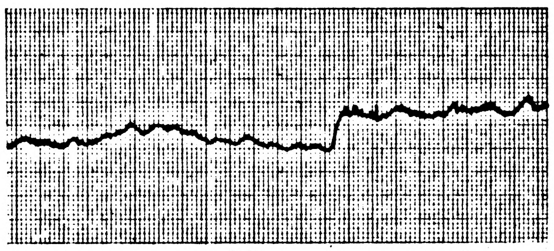
Probable Cause

Varnish
Debris

A power variation induced by debris or varnish, not as common as 3d but a positive indicator of an incipient failure.

Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

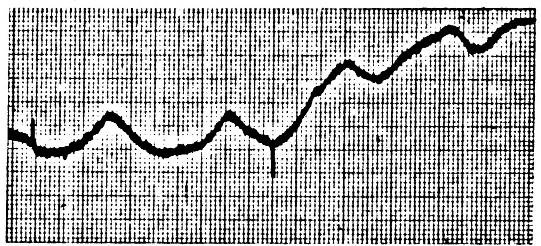


3f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



3g

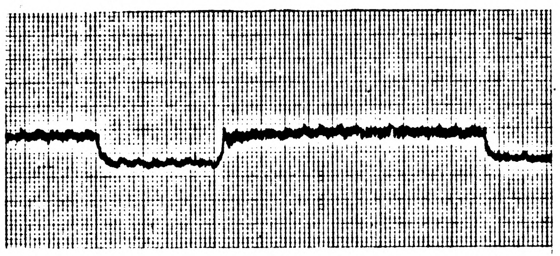
Probable Cause

Varnish

This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

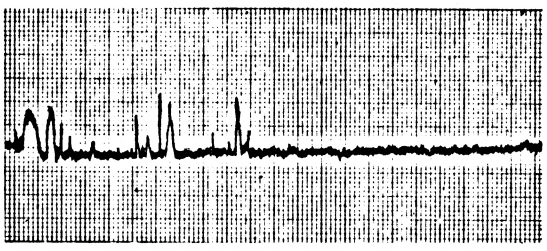


3h

Probable Cause

One Ball Group
Changing Angular
Velocity

Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



3i

Probable Cause

Squeal

Chart Speed	5 mm/min or 3 mm/min
Recorder Calibration	4 mw/mm (total power)
Recorder Time	
Constant	1. 3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

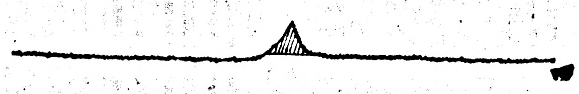


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.2.

APOLLO II IRIG Specification
~~ATP 2021500~~, MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
12-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13	[illegible] 2/24/65	[illegible] 2/4/65
9-20-65	C	22843	5, 6, 7, 9, 10, 11, 12	WK	[illegible]
10-8-65	D	23195	11, 12	WK	N/A
11-12-65	E	25210	10	WK.	▲ C. METZGER

This specification consists of pages i to ____ and 1 to 13 inclusive.

Rev B 12/21/64
Rev A Revised and Rewritten 10-24-64
Rev C 9/9/65

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

1. Sub-Assemblies and Parts to be Demagnetized
   - A. All magnetic parts prior to final assembly.
   - B. Float Assembly, Dwg. 2021619.
   - C. End housing assemblies, Dwg. 2021663 and 2021649.

2. Float Preparation
   - A. Cementing the rotors to the stub shaft.
     1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
     2) Assemble the rotors to the float to insure proper seating.
     3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
     4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
     5) TG rotor should be aligned per MC 25-618 step A, 11.
     6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
     7) Place assembly in oven and cure for 1-1/2 hours minimum at $150^{\circ} \pm 5^{\circ}$F.
     8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

     TG End ______________ TIR
     SG End ______________ TIR

     Maximum allowable runout on either end 0.0005 TIR.

3. Float Measurements
   - A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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4. Flotation
   - A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

     Weigh the float and record ____________ gm.

   - B. Determine the neutral buoyancy, end for end and rotational balance as follows:
     1) Place the float in an oven at 140°F for about 15 minutes.
     2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
     3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
     4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

     Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

     B Weight in air of solder on holder at TG end ________________.

     B Weight in air of solder on holder at SG end ________________.

     Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

     Weight (in air) added to TG end ____________
     Material ____________
     Weight (in air) added to SG end ____________
     Material ____________
     Total float weight in air ____________

     5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

     Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

   - C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

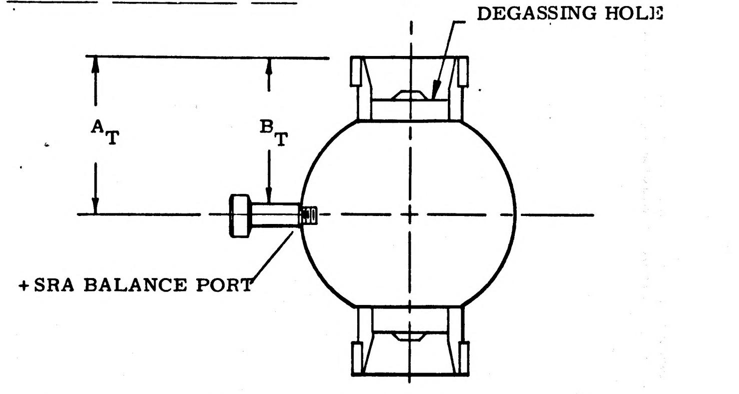
To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

NOTE: Plummets may be used to check fluid density while performing flotation.

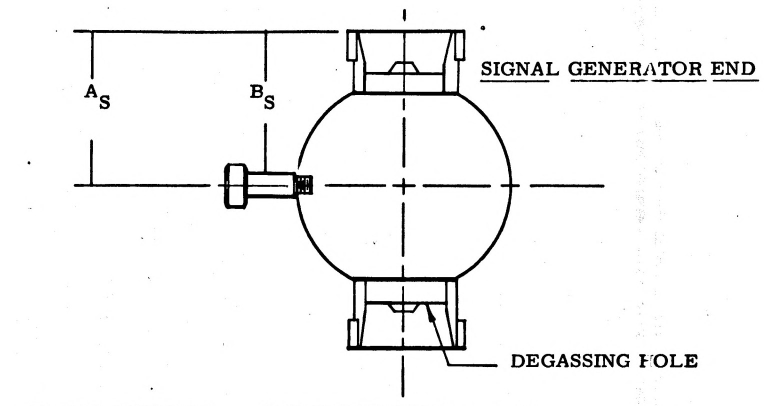
- D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.
- E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.
- F. Leak check and record ______________ atm-cc/sec.
  Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

FLOAT MEASUREMENTS

TORQUE GENERATOR END



A_T ________ = B_T ________ + .1250



A_S ________ = B_S ________ + 1250

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5. Main Housing Preparation
   - A. Lap the balance adjuster locking screws and the 00-96×5/32 long screws using 305A lapping compound.
   - B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly
   - A. End Cap Assembly
     - 1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.
     - 2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.
     - 3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.
     - 4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.
   - B. Thermistor Installation
     - 1) Procure thermistor per 2021518-1.
     - 2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)
     - 3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation
   - A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.
   - B. Check the fit of the damping blocks to the main housing.
   - C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:
     - A. K&D #100 round nose for spreading.
     - B. K&D #106 flat for staking eyelet to counterbore.
     - C. K&D #108 flat for staking eyelet head.

   - D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.
   - E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.
   - F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.
   - G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.
   - H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation
   - A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.
   - B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring
   - A. Mount a damping block assembly to fixture B-92316.
   - B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.
   - C. Lay a piece of flat pegwood across the center of the flex lead.
   - D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.
   - E. Repeat A through D for the second damping block.

10. Air Gap Measurements
    - A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing
    - A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_S and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_S in the support block A-118435.

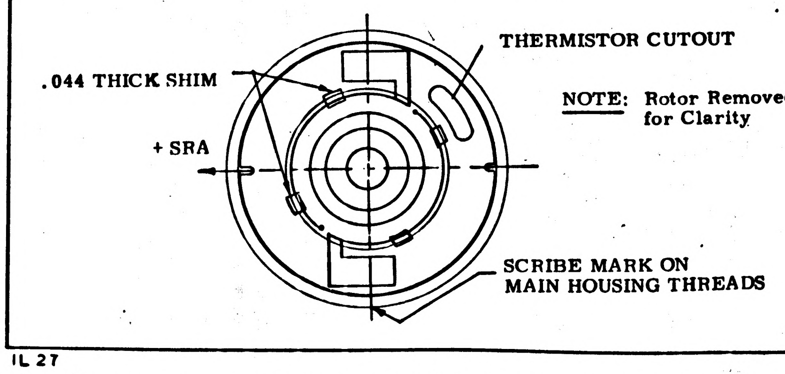
Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

   - B. Carefully lower the float into the main housing, with the torque generator up, the B- facing the assembler and + SRA to the left.
   - C. Insert the dummy stop pin A-92284 into the + SRA balance port, and secure it with a locking screw.
   - D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer.

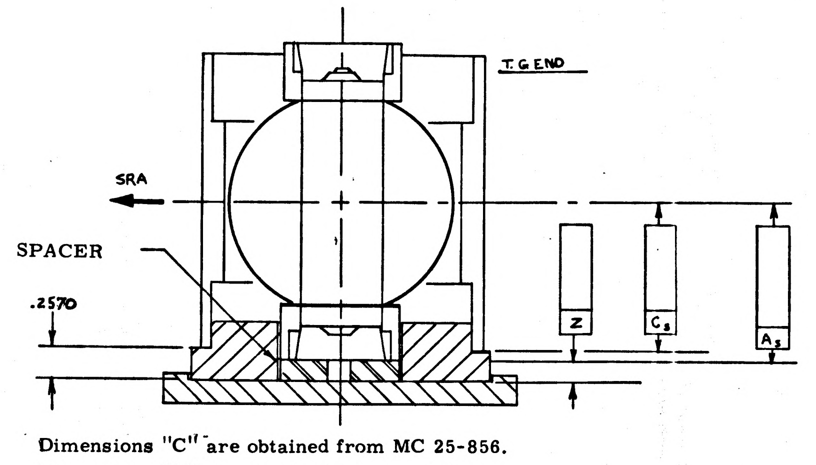
12. Torque Generator End Damping Block Assembly
    - A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.
    - B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.
    - C. Use the two shims A-87335 to support the weight of the flex lead as shown below.
    - D. Apply a small amount of #1571 Kester flux to each float terminal.
    - E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

      Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

      Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.



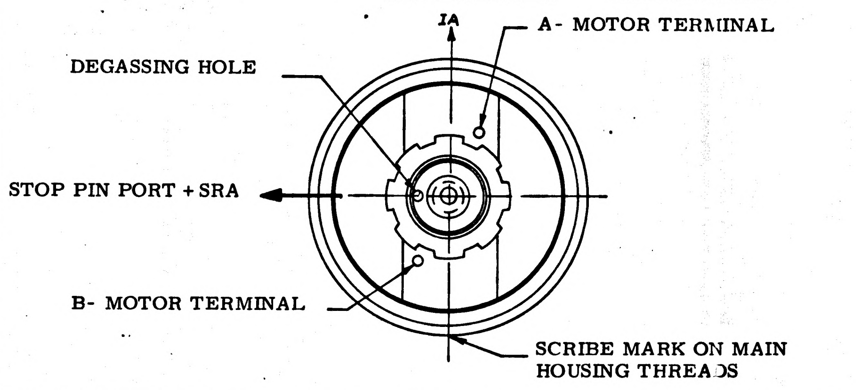
NOTE: Rotor Removed for Clarity



Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

Z_s = 0.2570 + C_3 ☐ - A_s ☐



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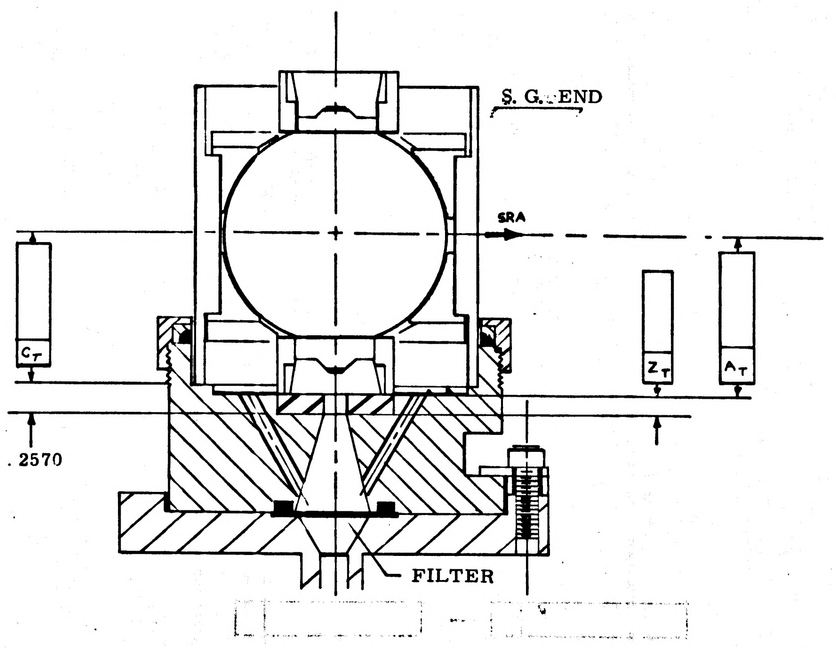
13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



Z_T = 0.2570 + C_T ☐ - A_T ☐

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O.D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O.D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

B H. Solder the flex leads to the float terminals as before.

14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 50 microinches.

E. Apply Damping Fluid (MC 25-612) sparingly to the pivot body and then wipe thoroughly with lens tissue. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut.

17. Dry Centering

A. Dry center the instrument as per MC 25-854.

18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 50 in-lbs. Invert unit and repeat above procedures. D

19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page #13.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964

MC 25-853

SHEET 12
OF 13

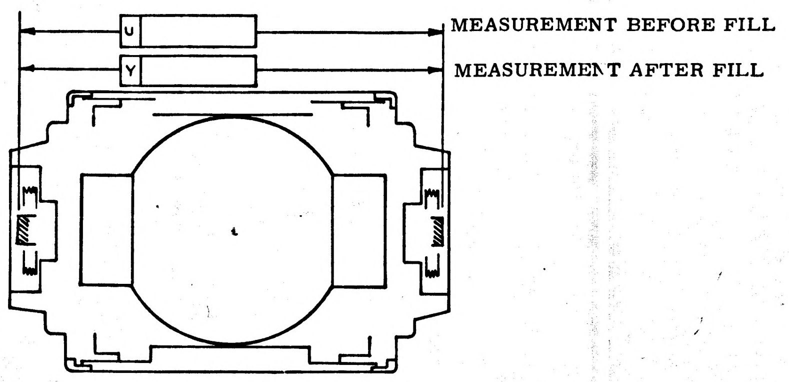
CB **20.** Bellows Measurement

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)-- ☐ Grams

IL 27

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64

MC# 25-853

SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_y					
S_H TO S_L						T- TO T_y					
S_L TO SSQ1 SEC						T_y TO T_c					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

B

MOTOR CIRCUIT

A- TO A+						
B- TO B+						
A- TO B-						
A+ TO B+						

IL 27

APOLLO II IRIG Specification
MC 25-854 E
Release Date 18 Nov, 1964
Release Revision A
Class A Release
TDRR 14363

Apollo II IRIG
Dry Centering Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/13/65	B	18306	1	WK.	
1/25/66	C	27251	2	WK.	
3/22/66	D	27337	2	WK.	A. C. METZGER
Ⓜ 1/9/68	E	35967	ALL	PRK	

TP#11938

This MC specification consists of page 1 to ___ and 1 to 11 inclusive.

APOLLO II IRIG DRY CENTERING PROCEDURE

1.0 PRELIMINARY

1.1 Mount unit in Fixture D-87262 with +SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Fig. 1 and check continuity through cabling.

1.3 Heat unit to $150^{\circ} \pm 5^{\circ}F$ and maintain temperature.

1.4 Connect gyro per Fig. 2 and excite at 10v.

1.5 Using the pivot adjusting fixture, center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position. With the suspension currents equal, adjust the working capacitors as required until each suspension current lags its voltage (measured from low side of swamping resistor) by $70 \pm 2^{\circ}$. Determine the average value of the working capacitors and set all eight capacitors equal to this average value within $\pm 1/2\%$.

1.6 Ensure that the balance paddles are rotationally centered in the 12-72 balance weights.

1.7 With the gyro in the SRA down position note the phases of the radial signals. Rotate the gyro to the SRA up position and ensure that each of the radial signals undergoes a phase reversal. Failure to achieve a phase reversal on each of the radial signals indicates a restricted travel which must be corrected before continuing.

2.0 ANGULAR ALIGNMENT OF MICROSYNS

2.1 Excite the gyro according to Fig. 3 and orient OA horizontal SRA down.

2.2 Drive the float between angular stops by torquing electrically per Fig. 5. Nominal torquing current is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 87:622 until the angular stop voltages are equal within 10 mv.

2.4 Note the SG secondary output voltage and scope lissajous pattern and gently tap the unit holding fixture until the lissajous indicates that the in phase component of the SG output voltage is ≤ 5 mv peak-to-peak.

2.5 Excite the TG as in Fig. 3. Keep the SG secondary at null (step 2.4) and slowly rotate the TG end housing in the direction to achieve a signal such that V_0 is at the TG null voltage within 2 mv or V_0 is within 2 mv of the value, and has the same relative phase as in step 3.5 of MC 25-860 if this value is higher than null.

2.6 Use an adjustable C-clamp as a tool and clamp the end housing tightly to the main housing. The parts should bottom to give a line-on-line fit when examined with an eye loupe or with a minimum of 10X magnification.

2.7 Remeasure the angular stop voltages (2.3), and null alignment 2.4-2.5. Make any necessary adjustments to end housings.

3.0 RADIAL CENTERING CHECK

3.1 Excite the gyro as in Fig. 2 and repeat step 1.7. Record the phase and magnitude of the radial signals. The maximum acceptable centering ratio is 6:1. (Note that the maximum acceptable centering ratio after cementing and curing is 6:1. The centering ratio is determined according to section 6.1 sheet #6. Make no entries on sheet #6 at this time.)

4.0 SETTING END SHAKE

4.1 Excite the unit per Fig. 4.

4.2 Repeat the procedure of step 1.5.

4.3 With the unit OA up and at 45° to the vertical, adjust the TG pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 25 ± 1 ma. Adjust the SG pivot, if necessary, to ensure that the float does not become locked between the pivots.

4.4 Using the axial sensitivity of 0.337 ma/.0001", retract the TG pivot until the SG suspension current shows a decrease of 2.0 ± 0.5 ma. This represents one-half the total end shake ($0.337 \times 6.0 \times 10^{-4} = 2.0$ ma).

4.5 Slowly rotate the gyro until the OA is down and at 45° to the vertical.

4.6 Adjust the SG pivot until the suspension currents are equal at 25 ± 1 ma. Then, using the same calibration, retract the SG pivot until the SG current decreases by 2.0 ± 0.5 ma.

ALLOWABLE END SHAKE = $0.0012 \pm 0.0003''$

APOLLO II IRIG Specification
MC 25-854
Release Date 18 Nov. 1964
Release Revision A
Class A Release
TDRR 14363

Apollo II IRIG
Dry Centering Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/13/65	B	18306	1	WK.	
1/25/66	C	27051	2	WK.	
3/22/66	D	27337	2	WK.	A. C. METZGER
1/9/68	E	35967	ALL		

TP#11938

This MC specification consists of page i to____and 1 to 11 inclusive.

APOLLO II IRIG DRY CENTERING PROCEDURE

1.0 PRELIMINARY

1.1 Mount unit in Fixture D-87262 with +SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Fig. 1 and check continuity through cabling.

1.3 Heat unit to 150° ± 5°F and maintain temperature.

1.4 Connect gyro per Fig. 2 and excite at 10v.

1.5 Using the pivot adjusting fixture, center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position. With the suspension currents equal, adjust the working capacitors as required until each suspension current lags its voltage (measured from low side of swamping resistor) by 70 ± 2°. Determine the average value of the working capacitors and set all eight capacitors equal to this average value within ±1/2%.

1.6 Ensure that the balance paddles are rotationally centered in the 12-72 balance weights.

1.7 With the gyro in the SRA down position note the phases of the radial signals. Rotate the gyro to the SRA up position and ensure that each of the radial signals undergoes a phase reversal. Failure to achieve a phase reversal on each of the radial signals indicates a restricted travel which must be corrected before continuing.

2.0 ANGULAR ALIGNMENT OF MICROSYNS

2.1 Excite the gyro according to Fig. 3 and orient OA horizontal SRA down.

2.2 Drive the float between angular stops by torquing electrically per Fig. 5. Nominal torquing current is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 872622 until the angular stop voltages are equal within 10 mv.

2.4 Note the SG secondary output voltage and scope lissajous pattern and gently tap the unit holding fixture until the lissajous indicates that the in phase component of the SG output voltage is ≤ 5 mv peak-to-peak.

2.5 Excite the TG as in Fig. 3. Keep the SG secondary at null (step 2.4) and slowly rotate the TG end housing in the direction to achieve a signal such that V_O is at the TG null voltage within 2 mv or V_O is within 2 mv of the value, and has the same relative phase as in step 3.5 of MC 25-860 if this value is higher than null.

2.6 Use an adjustable C-clamp as a tool and clamp the end housing tightly to the main housing. The parts should bottom to give a line-on-line fit when examined with an eye loupe or with a minimum of 10X magnification.

2.7 Remeasure the angular stop voltages (2.3), and null alignment 2.4-2.5. Make any necessary adjustments to end housings.

3.0 RADIAL CENTERING CHECK

3.1 Excite the gyro as in Fig. 2 and repeat step 1.7. Record the phase and magnitude of the radial signals. The maximum acceptable centering ratio is 6:1. (Note that the maximum acceptable centering ratio after cementing and curing is 6:1. The centering ratio is determined according to section 6.1 sheet #6. Make no entries on sheet #6 at this time.)

4.0 SETTING END SHAKE

4.1 Excite the unit per Fig. 4.

4.2 Repeat the procedure of step 1.5.

4.3 With the unit OA up and at 45° to the vertical, adjust the TG pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 25 ± 1 ma. Adjust the SG pivot, if necessary, to ensure that the float does not become locked between the pivots.

4.4 Using the axial sensitivity of 0.337 ma/.0001", retract the TG pivot until the SG suspension current shows a decrease of 2.0±0.5 ma. This represents one-half the total end shake ($0.337 \times 6.0 \times 10^{-4} = 2.0$ ma).

4.5 Slowly rotate the gyro until the OA is down and at 45° to the vertical.

4.6 Adjust the SG pivot until the suspension currents are equal at 25 ± 1 ma. Then, using the same calibration, retract the SG pivot until the SG current decreases by 2.0 ± 0.5 ma.

ALLOWABLE END SHAKE = 0.0012 ± 0.0003"

4.7 Slowly rotate the gyro to the OA vertical down position. Apply a small amount of Epon 828 adhesive (MC-25-303) around the pivot OD and end housing bore to form a complete fillet. (Optionally, sufficient cement may be applied so that, in addition to the complete fillet, at least part of the locking groove is filled when the cement is cured.) Slowly rotate the gyro OA up and at 45^{o} to the vertical and recheck axial signals. Readjust the TG pivot if necessary. Cure in this position per MC-25-303. Slowly rotate the gyro to the OA vertical up position. Repeat the cementing, rechecking and curing as before.

4.8 Remove the pivot adjusting fixtures and recheck end shake. The maximum acceptable axial centering ratio is 2:1.

5.0 CEMENTING CLAMPING RINGS

5.1 Recheck angular stops and microsyn alignments, readjusting as necessary (see Fig. 3).

5.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

5.3 Coat the threads on the clamping ring with Epon 828 and assemble to the unit. Wipe off excess cement.

5.4 Check the angular centering and make any necessary adjustments before the cement sets up. Keep the unit OA vertical with the cemented end up and cure per MC-25-303. The unit may be reoriented to OA vertical down after a minimum of 60 minutes.

5.5 Repeat 5.2 and 5.3 for the other end and cure per MC-25-303.

6.0 FINAL ALIGNMENT CHECKS

6.1 Repeat 3.0 recording (see data sheet) the phase and magnitude of the radial signals.

6.2 Recheck microsyn alignment, end shake, and SG microsyn stop voltages. Record these final values on the data sheet.

7.0 Refer to MC-25-853 for continuation of final assembly.

DATA SHEET

6.2 S.G. null voltage__________mv

V_o with S.G. at null__________mv ○ phase

(From MC 25-860, step 3.5) V_o________mv ○ phase

6.1		SGX________	TGX________
	SRA up	SGY________	TGY________
		SGX________	TGX________
	SRA down	SGY________	TGY________

Radial Centering Ratios ≦ 6:1

$\frac{S_{X\ max}}{S_{X\ min}}$________	$\frac{T_{X\ max}}{T_{X\ min}}$________
$\frac{S_{Y\ max}}{S_{Y\ min}}$________	$\frac{T_{Y\ max}}{T_{Y\ min}}$________

6.2 Final suspension currents

OA up and at 45° to vertical.

I_{SG_1}________ma

I_{TG_1}________ma

$\Delta I_{OA\uparrow}$\________ma

OA down and at 45^{0} to vertical

I_{SG_2}________ma

I_{TG_2}________ma

$\Delta I_{OA\downarrow}$\________ma

Centered currents

I_{SG} = ________ma

I_{TG} = ________ma

$\Delta I_{OA\uparrow} = I_{SG_1} - I_{SG}$ = ______ma

$\Delta I_{OA\downarrow} = I_{SG} - I_{SG\,2}$ = ______ma

Axial Centering Ratio (Spec ≦ 2:1)

$\frac{\Delta I\ max}{\Delta I\ min}$ = ________

(ΔI max is the larger value of ΔI OA↑ and ΔI OA↓. ΔI min is the smaller value.)

6.2 Cw Stop__________mv

CCw Stop__________mv

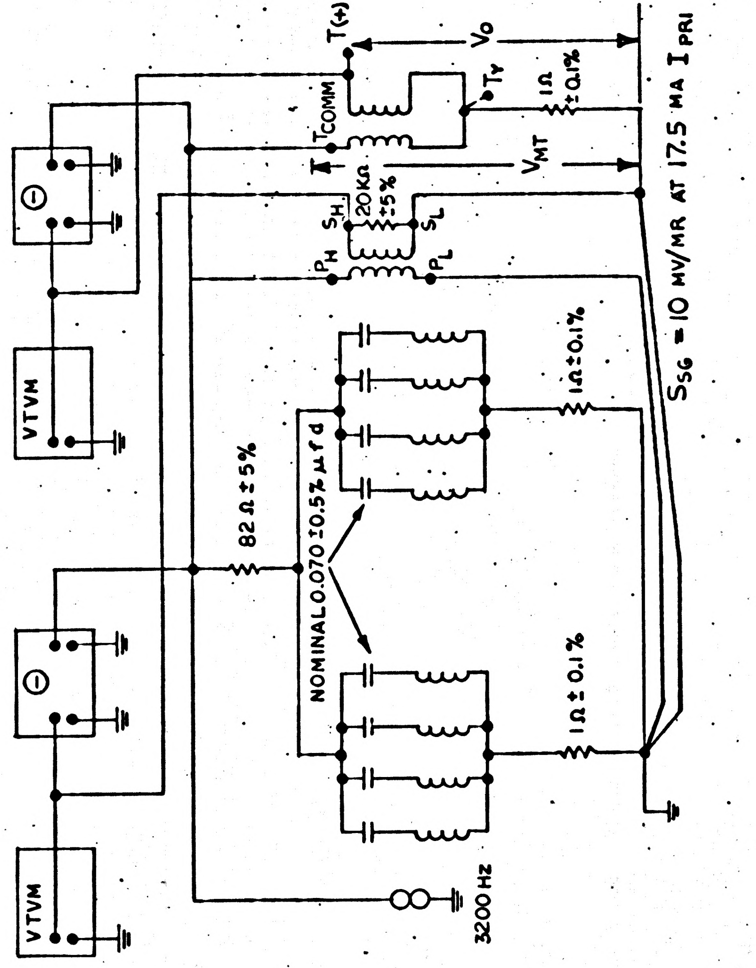


FIG. 1

4.7 Slowly rotate the gyro to the OA vertical down position. Apply a small amount of Epon 828 adhesive (MC-25-303) around the pivot OD and end housing bore to form a complete fillet. (Optionally, sufficient cement may be applied so that, in addition to the complete fillet, at least part of the locking groove is filled when the cement is cured.) Slowly rotate the gyro OA up and at 45° to the vertical and recheck axial signals. Readjust the TG pivot if necessary. Cure in this position per MC-25-303. Slowly rotate the gyro to the OA vertical up position. Repeat the cementing, rechecking and curing as before.

4.8 Remove the pivot adjusting fixtures and recheck end shake. The maximum acceptable axial centering ratio is 2:1.

5.0 CEMENTING CLAMPING RINGS

5.1 Recheck angular stops and microsyn alignments, readjusting as necessary (see Fig. 3).

5.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

5.3 Coat the threads on the clamping ring with Epon 828 and assemble to the unit. Wipe off excess cement.

5.4 Check the angular centering and make any necessary adjustments before the cement sets up. Keep the unit OA vertical with the cemented end up and cure per MC-25-303. The unit may be reoriented to OA vertical down after a minimum of 60 minutes.

5.5 Repeat 5.2 and 5.3 for the other end and cure per MC-25-303.

6.0 FINAL ALIGNMENT CHECKS

6.1 Repeat 3.0 recording (see data sheet) the phase and magnitude of the radial signals.

6.2 Recheck microsyn alignment, end shake, and SG microsyn stop voltages. Record these final values on the data sheet.

7.0 Refer to MC-25-853 for continuation of final assembly.

DATA SHEET

6.2 S.G. null voltage________________mv
V_o with S.G. at null________________mv ○ phase
(From MC 25-860, step 3.5) V_o__________mv ○ phase

6.1
SRA up SGX____________ TGX____________
SRA up SGY____________ TGY____________
SRA down SGX____________ TGX____________
SRA down SGY____________ TGY____________

Radial Centering Ratios ≦ 6:1

$\frac{S_{X\ max}}{S_{X\ min}}$____________ $\frac{T_{X\ max}}{T_{X\ min}}$____________

$\frac{S_{Y\ max}}{S_{Y\ min}}$____________ $\frac{T_{Y\ max}}{T_{Y\ min}}$____________

6.2 Final suspension currents

OA up and at 45° to vertical.
I_{SG_1}____________ma
I_{TG_1}____________ma
$\Delta I_{OA\uparrow}$____________ma

OA down and at 45° to vertical
I_{SG_2}____________ma
I_{TG_2}____________ma
$\Delta I_{OA\downarrow}$____________ma

Centered currents
I_{SG} = ____________ma
I_{TG} = ____________ma
$\Delta I_{OA\uparrow} = I_{SG_1} - I_{SG}$ = ______ma
$\Delta I_{OA\downarrow} = I_{SG} - I_{SG_2}$ = ______ma

Axial Centering Ratio (Spec ≦ 2:1)
$\frac{\Delta I\ max}{\Delta I\ min}$ = ____________
(ΔI max is the larger value of $\Delta I\ OA_\uparrow$ and $\Delta I\ OA_\downarrow$. ΔI min is the smaller value.)

6.2 Cw Stop________________________mv
CCw Stop________________________mv

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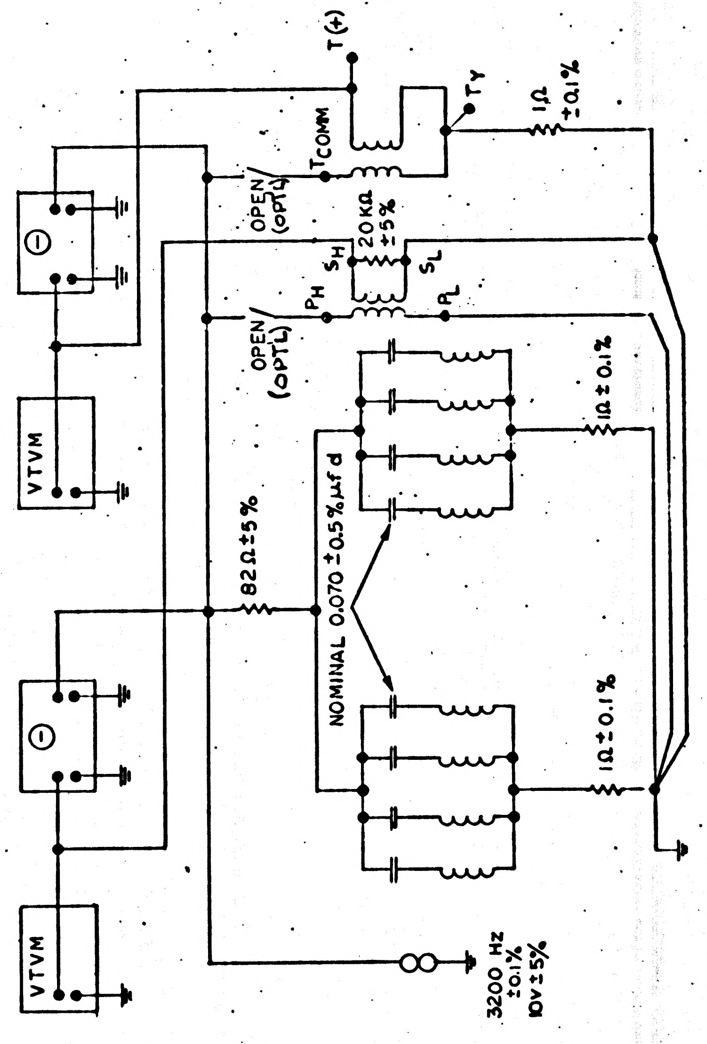
T(+)
TY
1Ω ±0.1%
TCOMM
OPEN (OPT'L)
SH
20KΩ ±5%
SL
PH
PL
OPEN (OPT'L)
1Ω ±0.1%
82Ω ±5%
NOMINAL 0.070 ±0.5% μfd
1Ω ±0.1%
VTVM
VTVM
3200 Hz ±0.1% 10V ±5%

FIG. 2 RADIAL CENTERING

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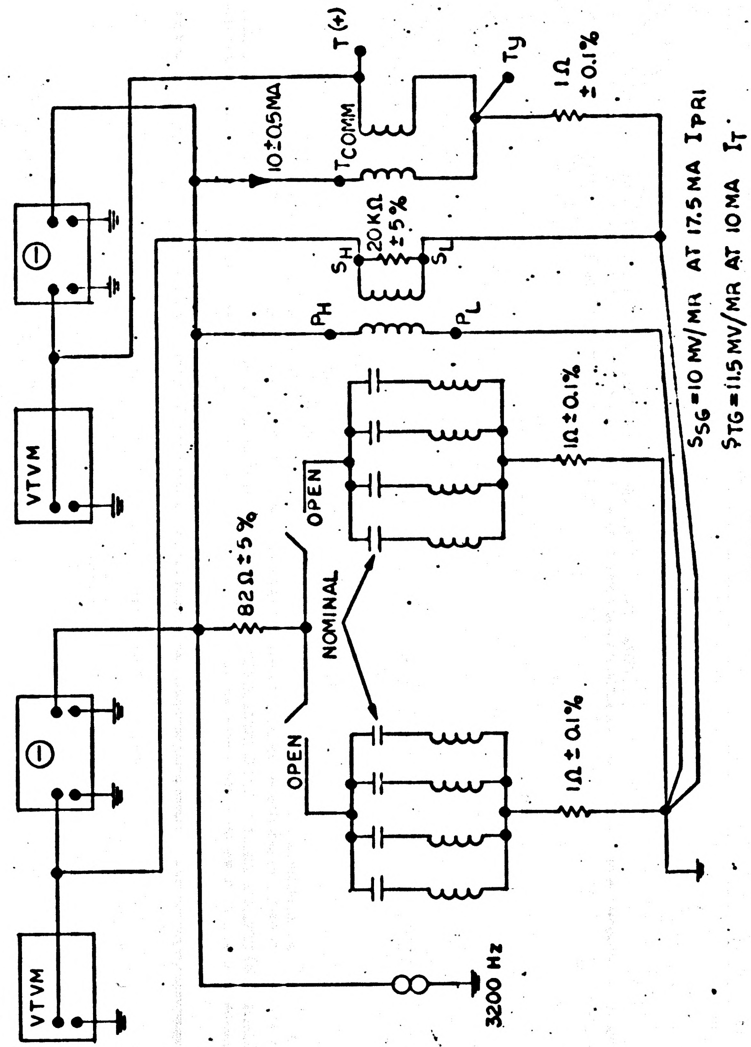
T(+)
Ty
1Ω ±0.1%
10±0.5MA
TCOMM
SH
20KΩ ±5%
SL
PH
PL
1Ω ±0.1%
OPEN
82Ω ±5%
NOMINAL
OPEN
1Ω ±0.1%
VTVM
VTVM
3200 Hz
SSG = 10 MV/MA AT 17.5 MA IPRI
STG = 11.5 MV/MA AT 10 MA IT

FIG. 3
SETTING SG ANGULAR STOPS
AND SG-TG NULL ALIGNMENT

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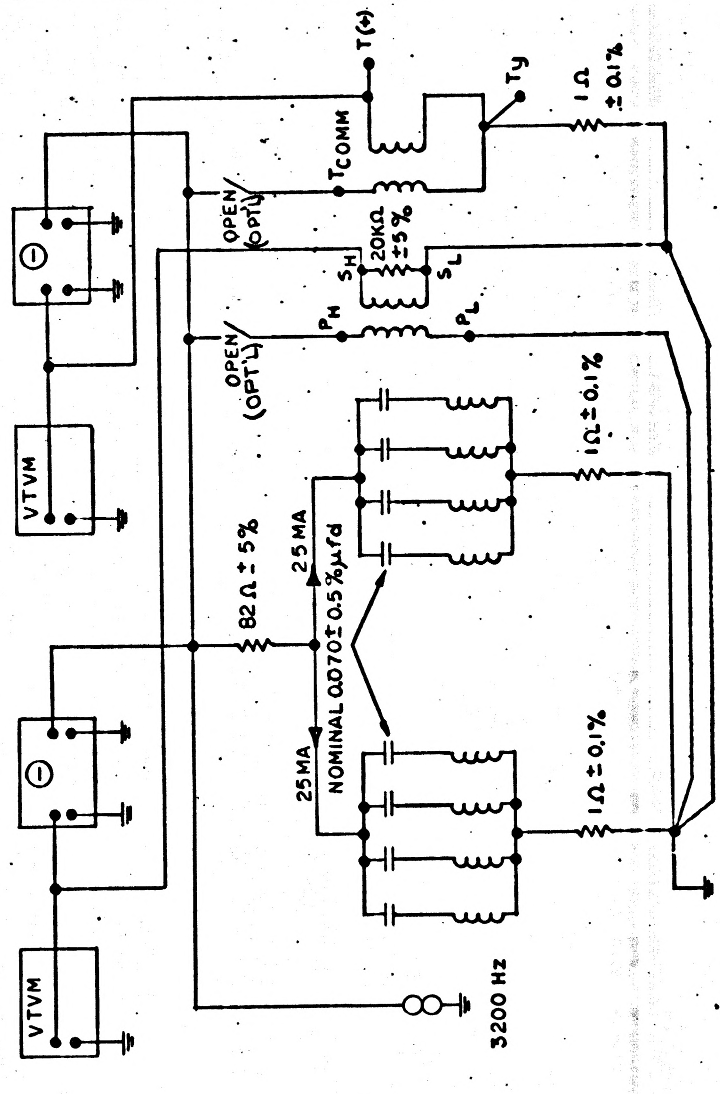
T(+)
Ty
1Ω ±0.1%
TCOMM
OPEN (OPT'L)
SH
20KΩ ±5%
SL
PH
PL
OPEN (OPT'L)
1Ω ±0.1%
82Ω ±5%
25MA
NOMINAL 0.070 ±0.5% μfd
25MA
1Ω ±0.1%
VTVM
VTVM
3200 Hz

FIG. 4
SETTING END SHAKE

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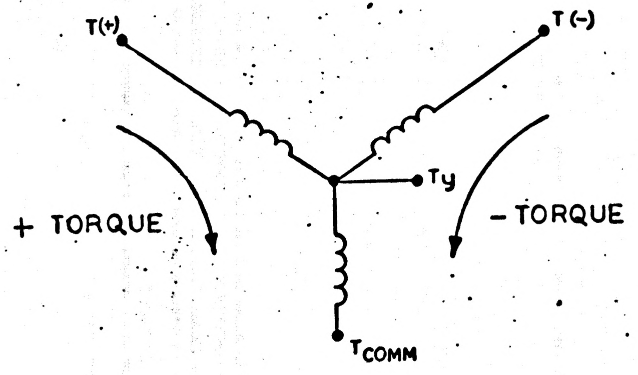
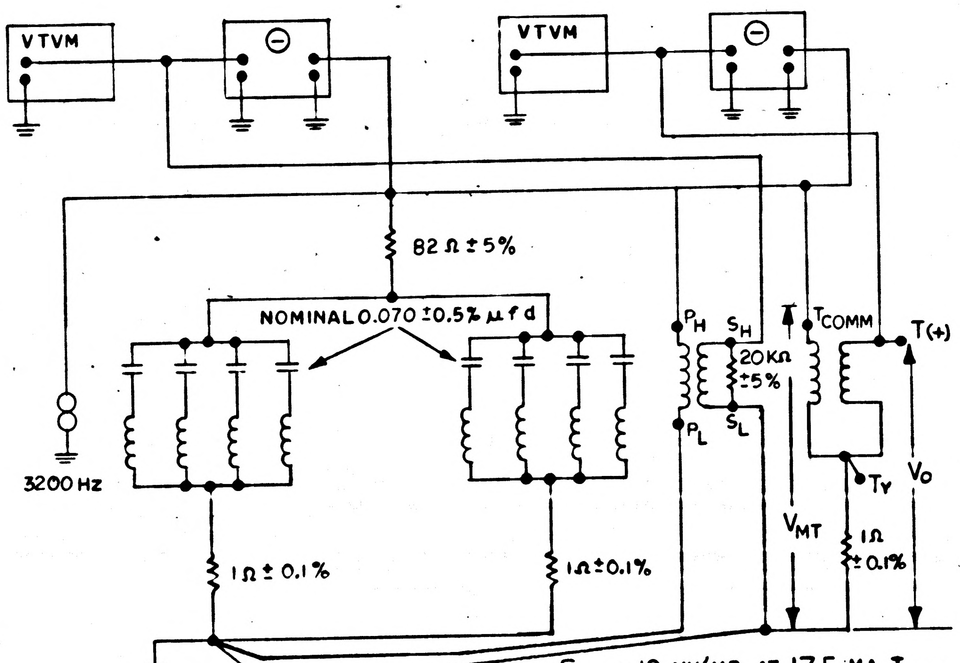
FIG. 5


T(+)
T(-)
Ty
+ TORQUE
- TORQUE
TCOMM

$S_{TG} = 0.6 \ \frac{\text{DYNE CM}}{\text{MA}^2}$


VTVM
VTVM
82 Ω ± 5%
NOMINAL 0.070 ± 0.5% μfd
3200 Hz
P_H
P_L
S_H
S_L
20 KΩ ±5%
T_COMM
T(+)
T_Y
V_MT
V_O
1Ω ± 0.1%
1Ω ± 0.1%
1Ω ± 0.1%

S_{SG} = 10 MV/MR AT 17.5 MA I_{PRI}

FIG. 1

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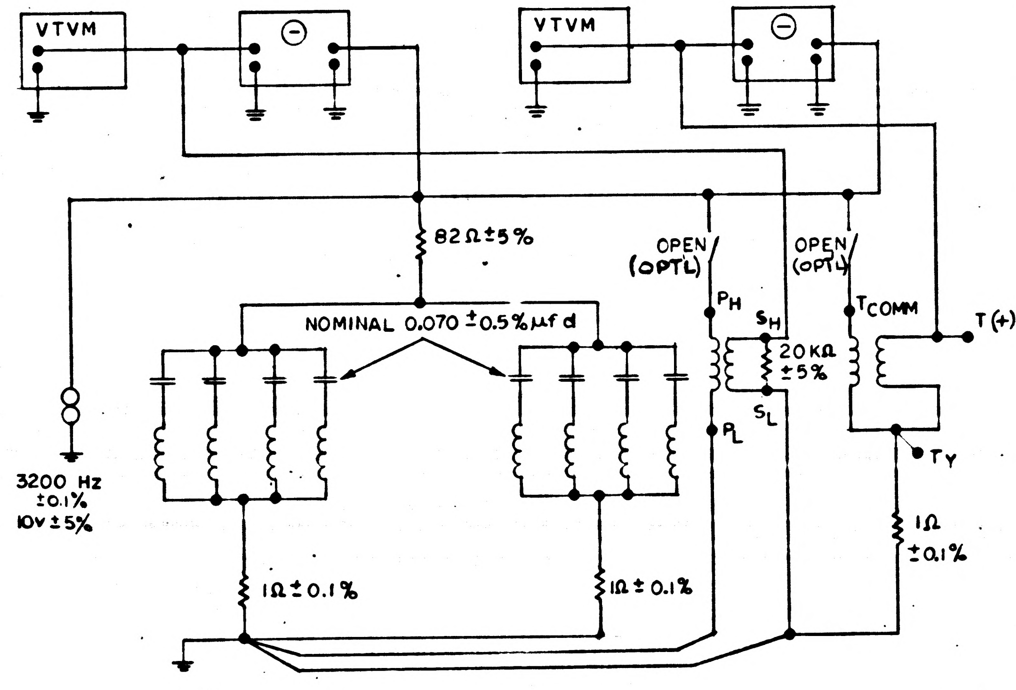
VTVM
VTVM
82 Ω ± 5%
NOMINAL 0.070 ± 0.5% μfd
3200 Hz ± 0.1% 10V ± 5%
OPEN (OPT'L)
OPEN (OPT'L)
P_H
P_L
S_H
S_L
20 KΩ ± 5%
T_COMM
T(+)
T_Y
1Ω ± 0.1%
1Ω ± 0.1%
1Ω ± 0.1%

FIG. 2 RADIAL CENTERING

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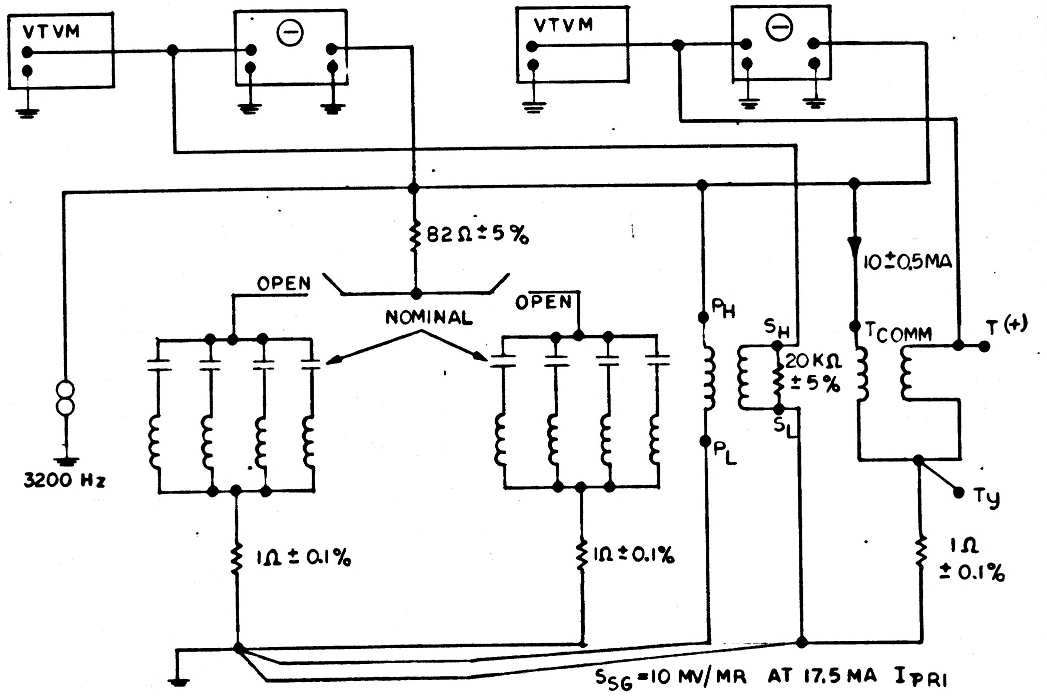
VTVM
VTVM
82 Ω ± 5%
OPEN
OPEN
NOMINAL
3200 Hz
P_H
P_L
S_H
S_L
20 KΩ ± 5%
10 ± 0.5 MA
T_COMM
T(+)
T_y
1Ω ± 0.1%
1Ω ± 0.1%
1Ω ± 0.1%

S_{SG} = 10 MV/MR AT 17.5 MA I_{PRI}

S_{TG} = 11.5 MV/MR AT 10 MA I_T

FIG. 3
SETTING SG ANGULAR STOPS
AND SG-TG NULL ALIGNMENT

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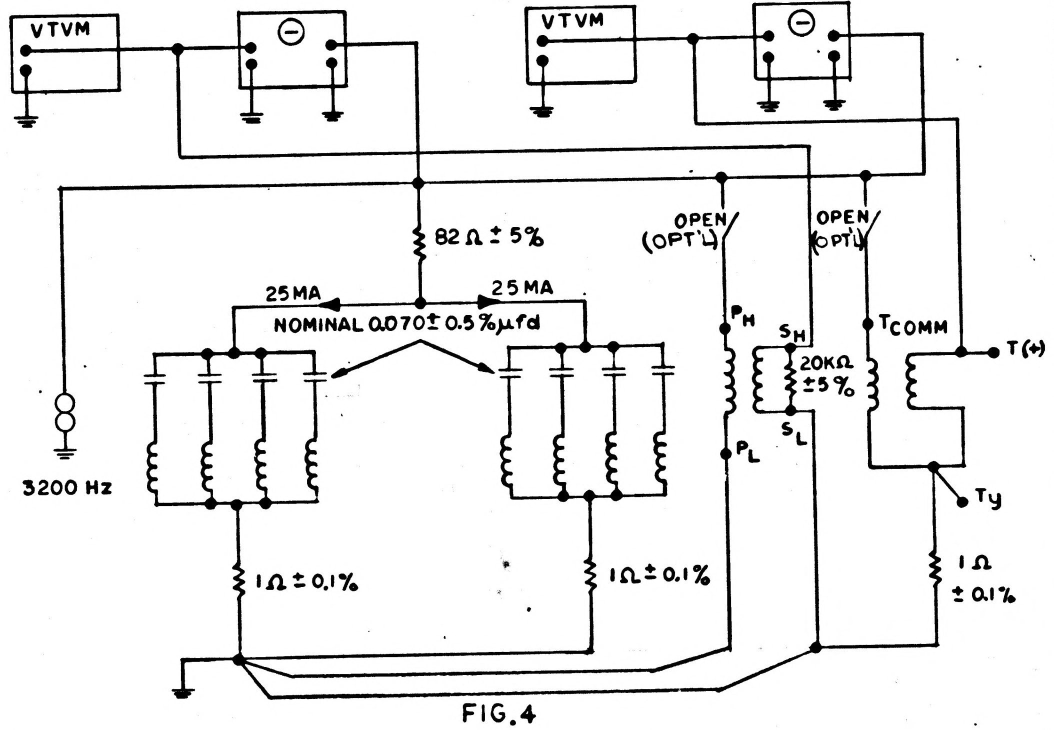
VTVM
VTVM
82 Ω ± 5%
25 MA
25 MA
NOMINAL 0.070 ± 0.5% μfd
3200 Hz
OPEN (OPT'L)
OPEN (OPT'L)
P_H
P_L
S_H
S_L
20 KΩ ± 5%
T_COMM
T(+)
T_y
1Ω ± 0.1%
1Ω ± 0.1%
1Ω ± 0.1%

FIG. 4
SETTING END SHAKE

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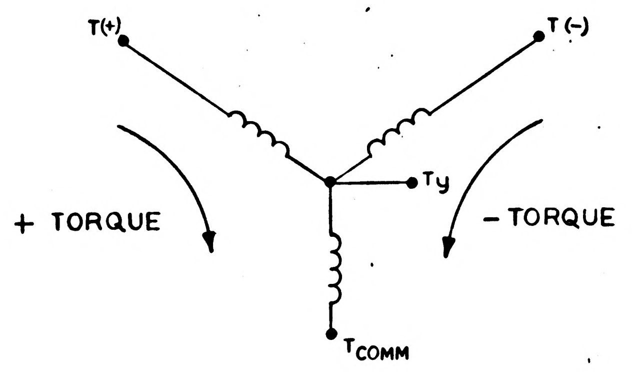
FIG. 5


T(+)
T(–)
Ty
+ TORQUE
– TORQUE
T_COMM

$S_{TG} = 0{,}6 \ \frac{\text{DYNE CM}}{\text{MA}^2}$

ORIGINAL

APOLLO II IRIG Specification
MC 25-855 REV E
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
4-30-65	B	18829.	1, 4, 5	WJK.	WJZ
3/21/68	C	35603	4, 5	DRK	✓ --
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8	DRK	--
1/31/69	E	37288	1-3	GBH/AC MGM EA	WLS

TP# 11938

This MC specification consists of page ~~i~~ ~~to~~___and 1 to 7 inclusive.

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.
2. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

   Record the O.D. of the wheel shaft. This information will be found in MC 25-605.

   +SRA ______________ -SRA ______________

   Record I.D. of hemisphere shaft bore

   +SRA ______________ -SRA ______________

   Average Interference

   +SRA ______________ -SRA ______________

3. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

   NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

4. Clean the #5-40 and #12-72 balance Weights, the two Bushings, the two Float Hemispheres, and the sealing screw by brushing them in clean trichloroethylene for a minimum of three (3) minutes. Ultrasonically rinse them in clean Freon for the same time period. Clean the Stator-Gimbal Assembly by brushing it in:
   a. varsol #2 at 70 to 95°F or
   b. trichloroethylene for a period not to exceed five (5) minutes at room temperature. Rinse the part in clean Freon.

   NOTE: The Stator-Gimbal Assembly is not to be ultrasonically cleaned in this or any subsequent operations.

5. Weigh all the float parts and record information on sheet #6.
6. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in Acetone followed by cleaning as in step #4.
7. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

   Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8. Measure and record the following:

   A) O.D. of stator ______________
   B) I.D. of gimbal ______________

   Subtract the gimbal I.D. from the stator O.D. and enter in "C".

   C) Average interference ______________(.0001-.0003)

---

9. Install the motor stator into the gimbal as follows:
   A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.
   B. Place the bushing A-92287 into the pressure plate.
   C. Assemble the motor stator to the pressure plate A-87423.
   D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.
   E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O.D.
   F. Remove the gimbal and fixture base from the hot plate.
   G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.

A H. Remove fixture and check centering of the stator in the gimbal. Check continuity. To be centered to within .005".

A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

10. Weigh gimbal and record ______________ gms.

A 11. Grind I.D. of motor stator as per drawing 2021625.

12. After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol (room temperature or warm 90°F ± 5°F) followed a thorough rinsing in clean freon. Trichloroethylene may be used instead of varsol #2 if the exposure time to the solvent is less than five (5) minutes at room temperature.

13. Weigh gimbal and record ______________gms.

A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

14. Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.
   A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ± 5° oven for 1/2 hour.
   B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O.D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F ± 5°.

   C. Repeat step "B" on oppostic end of gimbal.
   D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F ± 5°F.
   E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F ± 5°F.

15. Install .062 diameterball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10×10^{-8} ATM cc/sec. Leak rate ______________.

A 16. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt. cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10×10^{-8} ATM cc/sec. with a dwell time of one (1) hour at the extremes.
Leak rate ______________

17. Remove the sealing screw and .062 diameter ball from the degassing hole. Reassemble the #2-56 sealing screw to the gimbal. DO NOT TIGHTEN.

18. Assembly of wheel to float
   A. Thoroughly clean all the float parts, except the Inertial Element and Bearing Assembly, and the fixtures to be used by brushing them in clean filtered Freon.
   B. Mount the +SRA float hemisphere on fixture B-38921 and place on thermostatically controlled hot plate set to 350°F + 15°F and allow to heat for five or ten minutes.
   C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms.

A NOTE: Nylon gloves or finger cots to be worn when handling wheel.

19. Immediately remove from the hot plate and place on steel or brass block and allow to cool.
20. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.
21. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.
22. Heat the -SRA hemisphere as in "B" of step #17.
23. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

24. Carefully assemble the wheel and +SRA hemisphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

25. Balancing the float in Air

A A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

26. The float at this time is complete except for the rotors and balance weights. Weigh the float and record ____________ gms.

27. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T. I. R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 3.

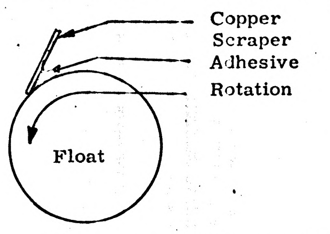
B 28. Refer to MC 25-803 or MC 25-869 or MC 25-880 for instructions on setting the +SRA bushing.

B 29. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ± 5°. oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.

Rev. B 4-30-65 (Revised & Retyped)



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 175°F ± 5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ± 5°.

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms.

B. Place a 2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

The following alternate procedure may be used:

Install float in fixture as described above. Draw a vacuum of 15" Hg and then admit helium to 0" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as above.

C. Weigh the float and record ____________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. __________ gms.

31. Leak check and record ____________ atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min. with a dwell time of one (1) hour at the extremes.

33. Leak check and record ____________

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

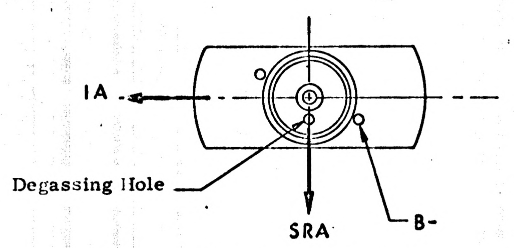
A 34. Refer to MC 25-803 or MC 25-869 or MC 25-880 for float run-in requirements.

FLOAT WEIGHT RECORD

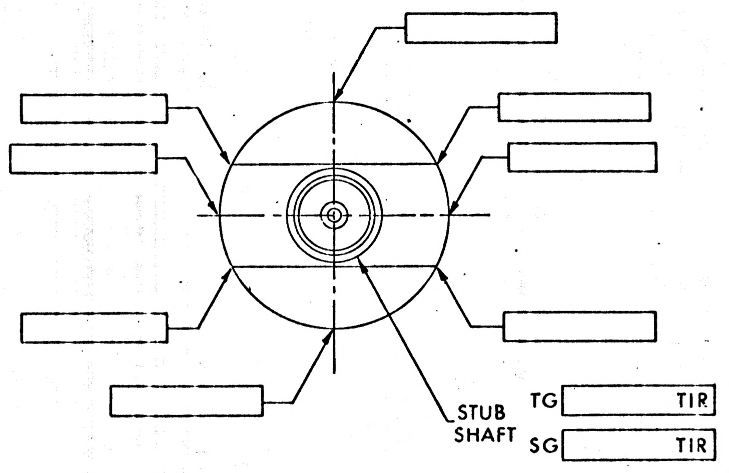
Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
A-87287	4	Power Lead-in		.092	
A-107251	8	Balance Weight (Final Rot. Adj.)		.740	
A-107252	4	Balance Weight Spring		.013	
A-87391	1	Centering Shim		.013	
B-87374	2	Bushing		1.676	
Comm'l.	1	#2-56 Sealing Screw		.037	
Comm'l.	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
C-87373	2	Hemisphere		14.701	
D-112977	1	Gimbal		26.051	
B-87289	1	Motor Stator (Finish Ground)		18.800	
C-118575	2	Rotor Assy. *		32.908	
C-87341	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
A-84046	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.



(View from T. G. End)



Runout of float sphere to pivots.

Rev. E 9/14/64
Rev. D 9/10/62
Revision C 5/31/62

FILLING PROCEDURE

(Refer to Drawing #2A3-10D130)

I. Sub-Assembly of Unit Mount

1. Clean all parts in accordance with M. C. #904.
2. Place sleeve (2A3-10A130. 50) on table with slotted end down.
3. Place "O" ring on tip of bottom plate and place bottom plate (2A3-10A130. 3) on sleeve and fasten with two 1/4-20 slotted head screws.
4. Place 3-56 set screw and . 078 ball into spotface provided in bottom plate.
5. Place filter mesh and filter ring 2A3-10A130. 11 into bottom plate.
6. Place "O" ring in groove in bottom plate.
7. Fasten guide plate 2A3-10A130. 4 to bottom plate with three #10-32 slotted head screws.
8. Reverse assembly after placing "O" ring in groove in guide plate.
9. Being certain aluminum ball and set screw are removed from bellows assembly, assemble spacer 2A3-10A130. 8 onto bellows clamp 2A3-10A130. 1 and thread assembly onto bellows until spacer contacts top of bellows.
10. Thread nut 2A3-10A130. 49 onto bellows clamp while holding spacer firmly with other hand to prevent clamp from turning, until nut contacts top of spacer.
11. Still holding spacer firmly, turn nut clockwise 3 turns. This will place bellows in 135°F. cap off position.
12. Reverse unit and repeat for other end.
13. Lower unit into sleeve and onto top of bottom plate.
14. Put "O" ring on top of bottom plate and place top plate onto unit. Clamp with two 1/4-20 slotted head screws.
15. Place 3-56 set screw and . 078 ball into hole provided in top plate.
16. Place "o" ring in groove provided in top plate.
17. Fasten overflow reservoir to top plate with three #10-32 slotted head screws.

---

18. Place glass cover on overflow cup.

II. Fixture Assembly

1. Lubricate the "L" gasket (2A3-10 X 130. 20) with vacuum grease (Dow Corning) and place it in position on the bell jar. This is best done by placing the bell jar in a horizontal position stretching the gasket entirely over the outside of the bell jar, and then slipping it over the end.
2. Assemble the freshly cleaned (see M. C. #904) parts of the filling apparatus as shown in drawing 2A3-10D130. Clamp gyro sub-assembly on as shown with three #10-32 socket head screws.
3. Place heaters and thermometers in upper block as shown. Set bell jar on the pump plate and cover with its guard.

III. Pumpdown

1. Open M valve. Close V valve. Star pump. The main system must be tight enough to obtain 5-15 microns with pump on.
2. Turn on lower and reservoir variacs and set them to achieve a temperature of 170°F. Watch the thermometers and adjust the voltages until the temperatures stabilize at 170° ± 5°F.

IV. Degassing of Fluid Charge

1. At about 38 hours of unit pumpdown, pour about 80 cc. of 2400/137/2. 385 Flotation Fluid (M. C. 25-612) heated to about 165°F into a 150 ml. beaker. Fill the Buchner Funnel* #1A3-10B129. 18 by vacuum applied to the filter end while the cone end is held under the fluid surface in the beaker. Keep the flask heated to 160-170°F. and apply a vacuum of 12 mm using degassing fixture 2A3-10C188. Degas until a vacuum of 12 mm can be maintained without over frothing. This operation will take approximately 45 minutes to 1 hour. Keep the fluid under vacuum with heat off until remainder of equipment is ready.
2. After 40 hours slowly vent the system to atmosphere, remove the bell jar and place the degassed fluid in the upper block. Replace bell jar with M and F valves open and V valve closed start pumpdown. Close F valve at 12 mm on vacuum gage.

Rest of system should pumpdown to 5-15 microns in one hour.

V. Filling

1. Start fill when the upper block temperature reaches 200°F.
2. Stop the pump, connect Freon Backfill Reservoir #B-100761 to vent as shown on sheet 7. Raise the bell jar pressure to 16 mm by carefully cracking the "V" valve. Close "M" valve. Remove Freon Backfill Reservoir.
3. Open the "F" valve and crack the "V" valve until Bourdon gage reads 5-10" of vacuum. Close "F" valve.
4. Control the flow rate into the "L" tube to about 25-30 drops per minute, by varying the vacuum in the funnel.
5. When the fluid begins to enter the instrument, reduce the rate of fluid flow to approximately 16 drops per minute. This rate should be varied as necessary to complete filling in 1 to 1 1/2 hrs.
6. When the fluid shows in the overflow cup, increase the flow rate and fill up the "L" tube. Continue the flush until there is 1/4" to 1/2" of fluid in the cup.
7. When step 6 is completed turn off heaters and vent both bell jar and funnel to atmosphere by opening F valve, and M valve and opening V valve slowly so that the return to atmospheric pressure should take no less than two minutes. Remove guard and bell jar.

VI. To Seal

1. Place 1/4" dia steel ball in overflow reservoir.
2. Remove heaters and thermometers from overflow reservoir.
3. Remove three screws and slide overflow reservoir from top plate onto clean aluminum plate.
4. Seal upper end of unit with . 078 dia. aluminum ball and #3-56 set screw.
5. Remove large "0" ring from top plate.

---

6. Remove three screws holding guide plate to mounting block and slide gyro unit assembly from mounting block onto clean aluminum block.
7. Invert gyro with guide plate up. Remove large "0" ring from the guide plate and remove a small amount of fluid with eye dropper to insure proper fit of "0" ring on piston.
8. Lower assembled weight #2A3-10A130. 5 and handle #2A3-10A130. 9 (previously heated to 160°F.) onto guide plate. Lower weight #2A3-10A130. 58 over handle. Press gently by hand several times with about one pound pressure to seat the 0-ring and to insure free piston motion. Leave on for 24 hours minimum at 160°F. Total weight should be approximately 15 pounds to give 150 psi.
9. To seal this end remove 3 screws holding guide plate to bottom plate and slide guide plate and weight from bottom plate.
10. Remove filter and filter ring from bottom plate and seal unit with . 078 dia. aluminum ball and #3-56 set screw.
11. Quickly remove the two screws holding bottom plate to sleeve and remove bottom plate. Loosen bellows clamp. Withdraw unit from sleeve and loosen other bellows clamp.
12. Using parts 4, 5, and 6 of bellows seal assembly 2A3-10B138, re-establish the torque on each seal to 50 inch-pounds.
13. Store in oven at 137°F.
14. Weigh and record filled weight.
15. Measure and record bellows overall length.
16. Unit now ready for thermistor calibration (M. C. 25-800).

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

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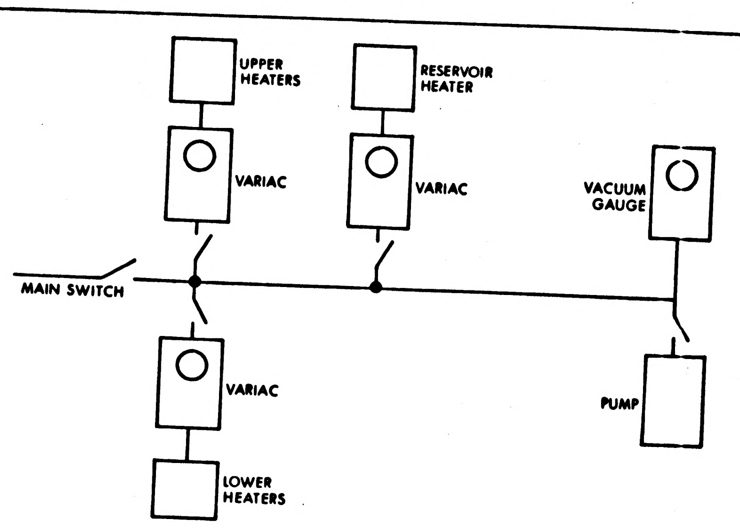
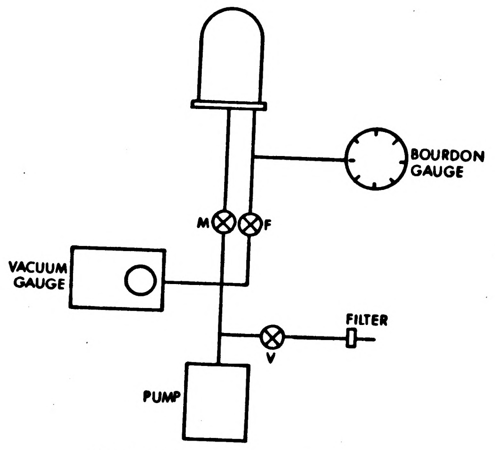
CAMBRIDGE, MASS.

PREPARED BY: R. Invernizzi
DATE: September 19, 1961
M. C. 25-816
SHEET 5
OF 8


UPPER HEATERS
RESERVOIR HEATER
VARIAC
VARIAC
VACUUM GAUGE
MAIN SWITCH
VARIAC
PUMP
LOWER HEATERS

a) ELECTRICAL SCHEMATIC


BOURDON GAUGE
M
F
VACUUM GAUGE
FILTER
V
PUMP

b) VACUUM PLUMBING SCHEMATIC

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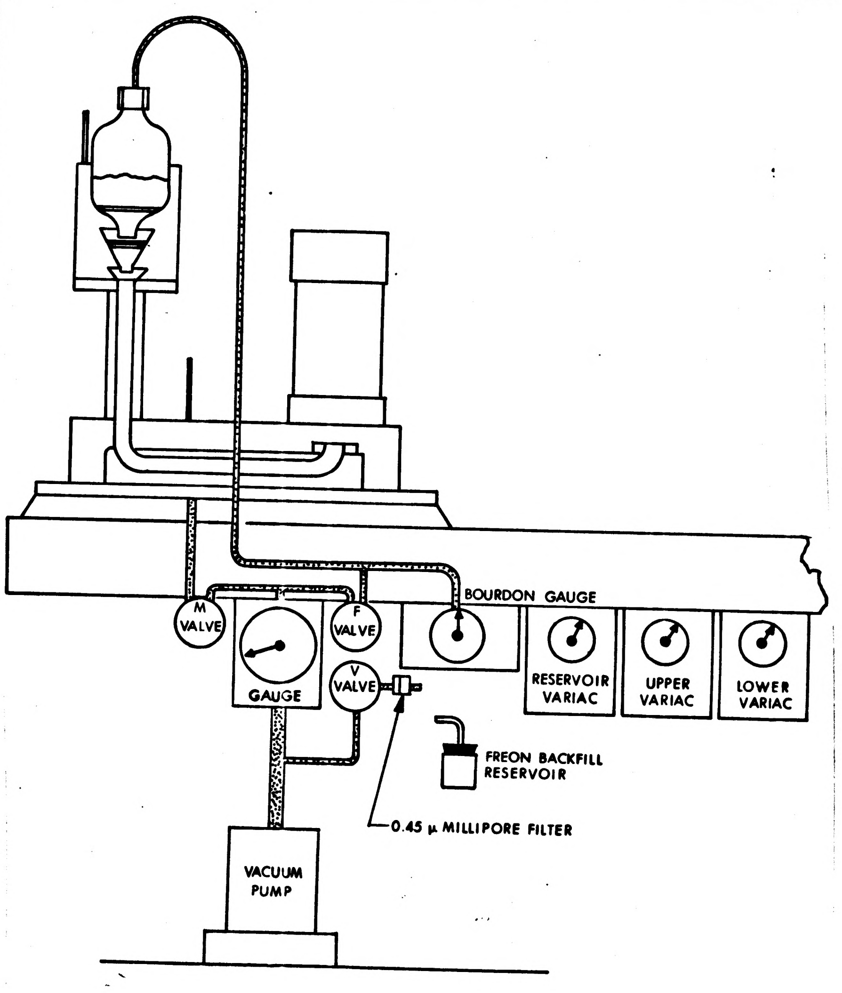
PREPARED BY: R. Invernizzi
DATE: 9. 19. 61
M. C. 25-816
SHEET 6
OF 8


BOURDON GAUGE
M VALVE
F VALVE
V VALVE
GAUGE
RESERVOIR VARIAC
UPPER VARIAC
LOWER VARIAC
FREON BACKFILL RESERVOIR
0.45 μ MILLIPORE FILTER
VACUUM PUMP

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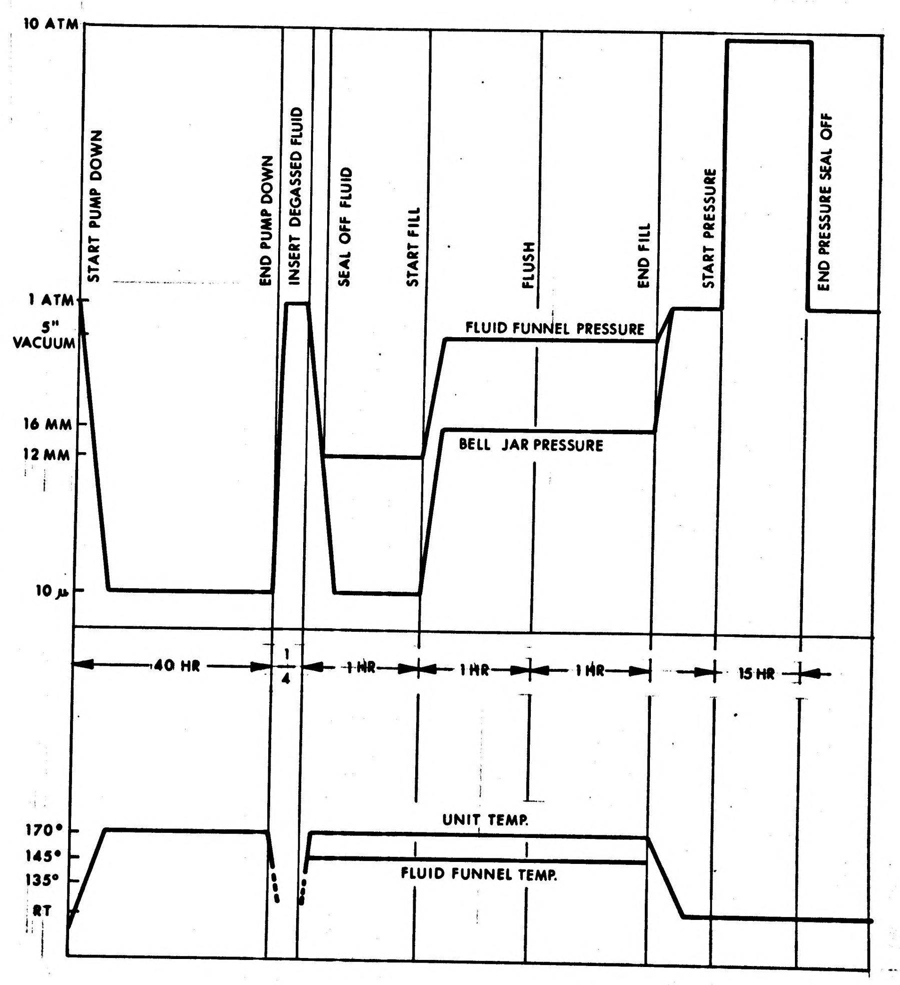
PREPARED BY:
DATE:
M. C. 25-816
SHEET 7
OF 8



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Ervin Lewis
DATE: February 11, 1959

Unit #
Fixture #
Filled by

FILLING RECORD
M. C. 25-816

Batch No.
Dens.
Vis.

SHEET 8
OF 8

DATE	TIME	ELAPSED	LIQUID PRESSURE mm	BELL JAR PRESSURE μ	TEMPERATURE L	TEMPERATURE R	TEMPERATURE U	METER VOLTS L	METER VOLTS R	METER VOLTS U	REMARKS

TP# 7427

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CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808
SHEET 1 OF 4

MT 1.3-302 MOTOR ASSEMBLY PROCEDURE

1. Stator Core

E Heat treat laminations B-62045 (2021674) per MC #105. Remove all burrs
B and throughly clean laminations according to MC 25-900. Bond laminations using fixture #2B3-10B12 per MC 25-300. There are approximately 33 laminations to a stator core. Coat all surfaces except O. D. with Hi-Dielectric Enamel by
E American Durafilm Co. (2021539) (2 coats 0.005 max. thick.).

2. Winding

Lap wind core as follows:

56 turns per coil of #35 A. W. G. aluminum wire, heavy silicone coated (2021540) 4 pole, 2 phase, 3 coils per pole per phase, 1-5 throw 2/3 pitch. Lap wind starting with phase B in slots 1-5 2-6 3-7; then phase A in slots 4-8, 5-9, 6-10. The slots are numbered C. C. W. as viewed from the side the leads come out.

3. Inserting Slot Cell Paper

D After the second coil of A phase has been wound (5-9), there will be two coil sides in slot #5. Insert slot cell paper dwg. A-107247 (2022158~~3~~) in slot #5 between winding and core. This is done by compressing the winding with a wedge-shaped wooden peg away from the slot opening on both sides of the core. Compress winding under slot opening by carefully pushing through a long pointed wooden peg between the winding and core. Insert the small end of slot cell paper in this space. Pull paper through from the opposite side until it fits snug. Cut paper on both sides as close to the core as possible. Paper should lie flat and extend equally on both sides of the slot opening.

Insert slot cell papers after each successive coil has been wound.

4. Location of Winding Leads

Looking at the finished-wound stator from the winding lead side (top side) and calling the slot having the first half turn of the first coil as slot #1, number the slots C. C. W. from 1 to 24. The four winding leads are identified

Rev. D 1/17/63
Rev. E 9/10/64
Rev. B 8/31/62
Rev. A 11/1/61
Rev. C 12/20/62

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CAMBRIDGE, MASS.

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808
SHEET 2 OF 4

as follows:
B+ Slot #1 B- Slot #21
A+ Slot #4 A- Slot #24

Check for continuity of each phase, for grounds in each phase, and for shorts between phases.

Position the winding leads as follows:

A+ to Slot #12 (bottom) A- to Slot #24 (bottom)
B+ to Slot #16 (top) B- to Slot #4 (top)

To bring B+ and B- to their respective slot positions, weave the leads through the winding so as to follow the winding pitch. Bring A+ to Slot #12 in the same manner and insert lead under slot cell paper. Position A- by removing one half turn and looping under coil. All winding leads should come out from the inside of the stator winding at the appropriate slot position.

Cut leads to 2" lengths and strip insulation with X-Var stripper down to about 1/4" from the top of the winding end turns. Clean stripped leads with Kimwipe (soft tissue) saturated with Denatured Ethyl Alcohol. Check for continuity, grounds, and shorts between phases.

5. Tin the four winding leads per MC 25-819.

6. Soldering Winding Leads to Terminal Leads

Use four 5" lengths of #35 A. W. G. H. F. copper wire for terminal leads. Strip, clean and tin 2" of each terminal lead. Insert terminal leads under slot cell papers at the appropriate positions so that they can be soldered to the winding leads. Pigtail the tinned portion of each winding and terminal lead. Solder pigtails using the tinning procedure of MC 25-819. Cut pigtails
E to 1/4" and insulate with Mylar tape or shrinkable sleeving per NASA dwg 1010490-120.

1010
7. Forming (Forming Fixture A-87414)

Use a wedge-shaped wooden peg and carefully form the O. D. of the winding on both sides so that it will clear the I. D. of top and bottom plates of forming fixture. Assemble stator to plates. Visually check assembly for pinched wires.

Form I. D. of stator on both sides so that it will clear O. D. of upper and lower supports. Assemble supports to stator and check for pinched wires. Lay the terminal leads on the top of the stator winding. Assemble forming

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CAMBRIDGE, MASS.

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808
SHEET 3 OF 4

fixture. Check for continuity, grounds and shorts between phases.

8. Connecting (Terminal Pins to Terminal Leads)

Strip, clean and tin the four terminal leads down to about 1/8" from the top of the winding end turns.

Clean the tinned terminal leads and four motor terminals with denatured ethyl alcohol.

E Hold terminal with a pair of tweezers and place a drop of Kester soldering Flux #1571 on top of terminal. Melt a small bead of 96.5 SN, 3.5 AG solder on soldering tip. Sweat solder into terminal hole until it is completely filled.

E C Place terminal insulator A-107246 (2021576) over terminal lead. Hold solder filled terminal with a pair of tweezers and sweat terminal down over the terminal lead to proper height. (Do not allow terminal to drop below the tinned portion of the terminal lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.

Check for continuity, grounds, and shorts between phases.

9. Assemble stator to potting mold per MC 25-504.

MC - 2508

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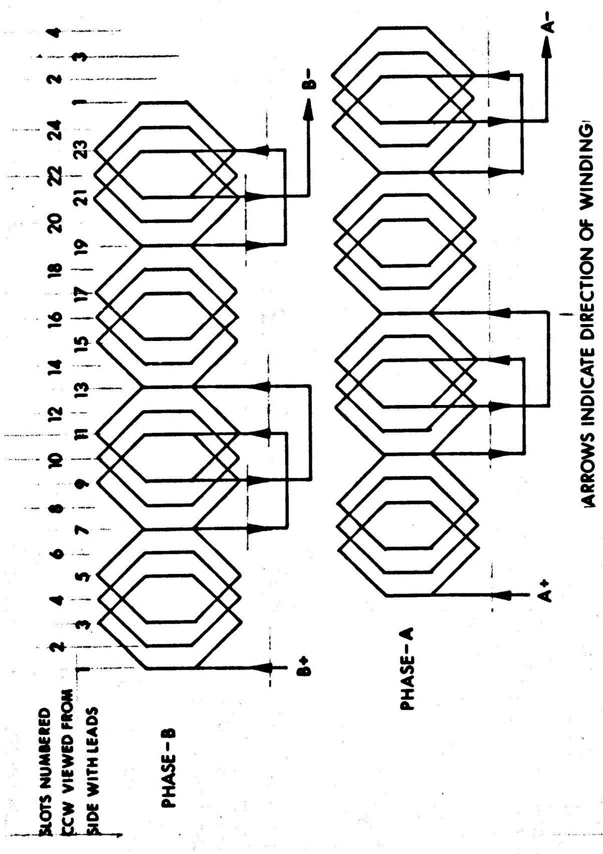
of 4

Fred Straccia
August 25, 1961
M.C. 25-808
Sheet 4 of 4



ARROWS INDICATE DIRECTION OF WINDING:

WINDING PROCEDURE:

WIND FROM TWO SPOOLS USING ONE CONTINUOUS LENGTH OF WIRE FOR EACH PHASE.

LAP WIND, STARTING WITH PHASE B IN SLOTS 1-5, 2-6, 3-7, ETC.
THEN PHASE A IN SLOTS 4-8, 5-9, 6-10, ETC.

EXCITATION PHASE ORDER A, B APPLIED TO TERMINALS A & B RESPECTIVELY WILL PRODUCE C.W. ROTATION FIELD VIEWED FROM THE SIDE WITH LEADS

4 - POLES
2 - PHASE
3 - COILS/POLE/PHASE
#35 - AWG HEAVY SILICONE COATED ALUMINUM WIRE
56 - TURNS/COIL
1-5 - COIL THROW
2/3 - PITCH

APOLLO II IRIG Specification
MC 25-859
Release Date Nov. 25, 1964
Release Revision A
Class A **Release**
TDRR 14531

Procedure for Testing
SG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
2/12/65	B	16568	1, 2	WK	JBm 2/17/65
3/18/65	C	17645	1, 2	WK	WJR
6/8/65	D	20017	1	WK	Jbm
12/5/68	E	37102	1	MGM EA	WLS

TP#11938

This MC specification consists of page i
and 1 to 2 inclusive.

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CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

MC 25-859 Rev E

SHEET 1
OF 2

Rev D 6/3/65
Rev. C 3/18/65
Rev. B 2/12/65
Rev. A 11/9/64

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5%F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Fig. 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

DB 2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1° and $I_m = 45.0 \pm 5.0$ ma.

A 2.5 Disable SG primary and measure suspension reaction torque. Record. Limit is 0±0.15 dyne-cm.

B 2.6 Note: End housings will be matched for suspension currents per MC 25-856, main housing assembly procedure.

3.0 Signal Generator

B 3.1 Reconnect per Fig. 1. Disable suspension, and increase V_{in} to 4.0 v.

A 3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating and recording the angular sensitivity and relative phase of E_o vs V_{in}.

IL 27

TDRR 14531 NOV 25 1964

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CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

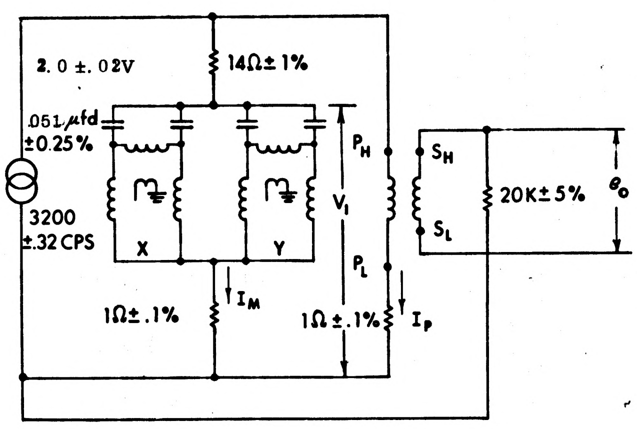
MC 25-859

SHEET 2
OF 2

3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.

A
B
C



No connections shall be made to quadrature or center tap tap terminals.

Fig. 1

IL 27

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APOLLO II IRIG Specification
MC 25-852 REV F
Release Date Jan. 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
5/7/65	B	18998	1, 3	WKF.	WJR
7/5/68	C	36502	All	PRL	
12/9/68	D	37098	2	MGM EA	RJJ
4/21/69	E	37525	Was 6 pages, All now 7 pgs	MGM EA	WLS
8/28/69	F	37777	1, 3	EA	MDH

TP#11938

This MC specification consists of page 1 to ___ and 1 to 7 inclusive.

ASSEMBLY OF SHROUD TO GYRO UNIT; APOLLO II
SHROUD END COVER ASSEMBLY

Equipment and Materials Required

450 Watt Hot Plate
50 Watt Soldering Iron Pyramid Tip
Variac
Solder - 96.5 Tin; 3.5 Silver
Solder - 60 Tin; 40 Lead
Flux - Kester 891 - Kester 1571
Artist Brush #3 - Acid brushes
Trichloroethylene
Freon
Ajax, Powdered Boraxo
305A and 38-1200 lapping Compound
#00 and medium grit polishing paper

1.0 End Cover Preparation

A. Rough up the areas to be tinned on all the shroud parts, using a medium grit polishing paper, steel wool or equivalent.

B. Clean all the parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, follow by an ultrasonic rinse in clean freon for the same time period.

C. Leak check the end covers for porosity using fixture: 2A3-10B182.0 (Optional)

2.0 Tinning Procedure

A. Place the end cover on hot plate and heat to 250°F ± 10°.

B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.

C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.

D. Repeat steps B and C on inside of cover.

E. Remove from hot plate and allow to cool.

3.0 Cleaning Procedure

A. With an acid brush scrub the end cover using clean trichloroethylene.

B. Follow by scrubbing under running hot water using Ajax, powered Boraxo or equivalent.

C. Thoroughly rinse under running hot water and dry.

4.0 Assembly of Seals to End Covers

A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux.

B. Refer to 1.0 para. "B" for cleaning procedure.

C. Place cover on hot plate and heat to 490°F± 10°

D. Tin the .125 diameter on the 16 terminal seals, 2021508, with Sn-[illegible]" solder and Kester 891 flux. Clean as in step 1.0 para "B".

E. Apply 1571 flux to tinned area.

F. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position.

G. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.

H. Carefully remove from the hot plate and allow to cool.

I. Repeat cleaning procedure #3.

J. Polish the end covers using 305A lapping compound, followed by 38-1200 compound. Final clean as in step #3.

K. Seal the degassing plug hole with the aluminum ball and seal screw, Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.

L. Hi Pot - 250 volts (DC).

M. Tin the 2.443 diameter on the end cover with SN-60 solder and Kester 891 flux. Clean as in step 3.0.

N. Meggar check the assembly 250 volts DC.

5.0 Main Cover Preparation

A. Tin the 2.440 diameter and two .010 deep relief with 60-40 Solder and Kester 891 flux.

B. Refer to step #3 for cleaning.

6.0 Insert Preparation

A. Tin concave side with 60-40 solder and 891 Kester flux.

B. Refer to step #3 for cleaning.

7.0 Internal Connector Assembly

A. Check the connector assembly for shorts or opens.

B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.

C. Carefully clean all joints with trichloroethylene and artist brush, followed by a freon rinse.

D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.

E. Leak check assembly as in "J" of step #4.

F. Apply LCA-9 adhesive (MC 25-302) over the glass seals and any exposed wires. Cure for two (2) hours minimum at 200°F ±5°.

G. Form the wires carefully at terminal to provide a 180° bend strain relief.

H. With lacing cord or shrink sleeving secure each pair of 8 wires in two places about one inch apart.

I. Make a final electrical check on assembly.

J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)

NOTE: Shrink sleeving is assembled to leads prior to soldering.

8.0 Assembly of the Shroud To Gyro Unit

A. Measure and record the bellows extension ______ in. at 135°F±5°.

B. Allow the gyro to cool down and remain at room temperature during the shrouding operation.

C. Carefully inspect the O.D. of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

D. Align the open ports in the main cover with the +SRA and +IA gyro axis.

E. Install the end cover assembly on the unit, carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

F. Perform an electrical check for correct resistances, opens and grounds. See note below.

G. Apply a minimum amount of 1571 Kester flux to main cover- end cover joint with a piece of solder or a small artist brush.

H. With a 50 watt soldering iron (Pyramid Tip) make the joint between the main cover and end cover.

I. Excess solder can be removed with a sharp edge dental tool, and hard rubber abrasive eraser.

J. Repeat steps "E" through I for remaining end cover. See note below.

K. Clean the joints by brushing with an acid brush and clean trichloroethylene, followed by a brushing with clean freon.

L. Perform complete electrical check of unit.

NOTE: Perform measurements required in Figure 1. Record last set of measurements.

9.0 Leak Check of Shrouded Unit

A. Carefully assemble the unit to the leak check fixture, C-127683.

B. Seal off the exposed end with the aluminum ball (17S-T4) and #2-56 x 3/32" long sealing screw. Leak check this end of the unit. Maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

C. Remove seal screw and aluminum ball.

D. Repeat steps "A" through "C" for the opposite end of unit.

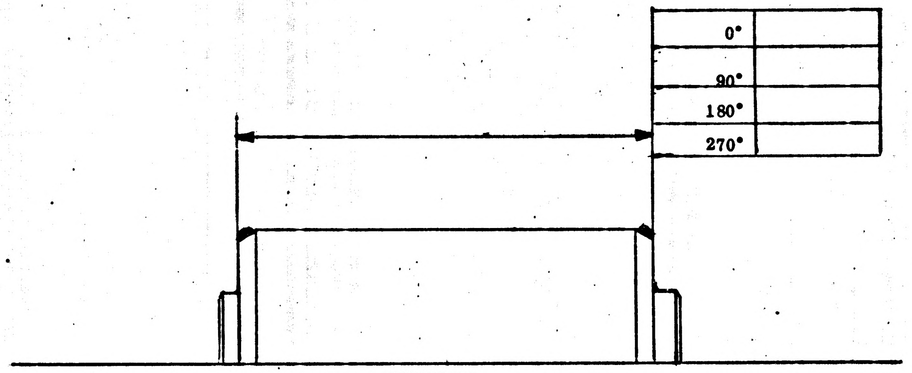

FIGURE 1

NOTE: DEGASSING SEAL SHOWN AT 0° POSITION.

10.0 Decals

A. Clean the ends of the shroud covers with a Kimwipe dampened with trichloroethylene. Remove the protective backing from the T.G. decal and fasten the decal to the T.G. shroud end cover. Aligning the IA arrow such that it is pointing toward the degassing seal. Smooth out the decal using finger pressure to eliminate ridges, air pockets, etc. Repeat the operation for the S.G. decal aligning the lettering such that it reads in a direction which is perpendicular to the degassing seal.

11.0 Preliminary Testing

A. Unit is ready for preliminary testing.

12.0 Final Shroud Sealing After Preliminary Testing

A. Cool gyro to room temperature.

B. Apply a minimum of Kester 1571 to the two (2) 0.010 inch deep reliefs on the sleeve and concave surface of the inserts.

C. Position the inserts on the sleeve so as to follow the general contour of the 2.460 diameter.

D. With a 50 watt soldering iron and Sn-60 solder, make the joint between the sleeve and inserts. Remove excess solder as before. Clean the joints with an acid brush and trichloroethylene, followed by a brushing with clean freon.

13.0 Final Leak Check of Shrouded Unit

A. With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S.S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683. Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the

---

terminals, ports and main seam at the end with helium. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

B. Remove the sealing screw and aluminum ball from the unit.

C. Invert the unit and leak check as before.

D. With the unit still on the leak check fixture and 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug. Remove the unit from the fixture and retorque both set screws to 28-30 in. oz.

E. Continue with final testing per PS 2021602 or PS 2021500, as applicable.

F. Store in a 135° ±5°F. oven awaiting delivery.

APOLLO II IRIG Specification
~~ATP 2021500~~, MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13		
7-23-65	C	22893	5, 6, 7, 9, 10, 11, 12	WK	
10-8-65	D	23195	11, 12	WK	N/A
11-12-65	E	25210	10	WK	A. C. METZGER
9-27-67	F	34995	10, 11	PRK	

This specification consists of pages i to ____ and 1 to 13 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1961

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

Rev B 12/21/64
Rev A Revised and Rewritten 10-24-64

1. Sub-Assemblies and Parts to be Demagnetized
   - A. All magnetic parts prior to final assembly.
   - B. Float Assembly, Dwg. 2021619.
   - C. End housing assemblies, Dwg. 2021663 and 2021649.
2. Float Preparation
   - A. Cementing the rotors to the stub shaft.
     1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
     2) Assemble the rotors to the float to insure proper seating.
     3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
     4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
     5) TG rotor should be aligned per MC 25-618 step A, 11.
     6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
     7) Place assembly in oven and cure for 1-1/2 hours minimum at 150°± 5°F.
     8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

TG End ____________ TIR
SG End ____________ TIR

Maximum allowable runout on either end 0.0005 TIR.

3. Float Measurements
   - A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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4. Flotation
   - A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

     Weigh the float and record ____________ gm.
   - B. Determine the neutral buoyancy, end for end and rotational balance as follows:
     1) Place the float in an oven at 140°F for about 15 minutes.
     2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
     3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
     4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

        Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

        B Weight in air of solder on holder at TG end ____________.
        B Weight in air of solder on holder at SG end ____________.

        Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884
Weight (in air) added to TG end Material	____________ ____________
Weight (in air) added to SG end Material	____________ ____________
Total float weight in air	____________

     5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

        Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.
   - C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

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Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

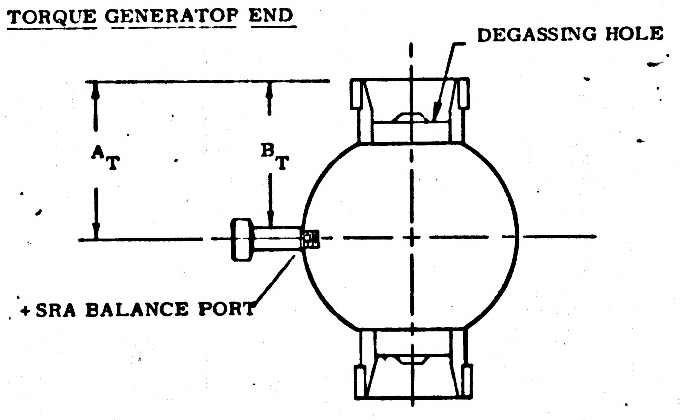
To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

NOTE: Plummets may be used to check fluid density while performing flotation.

- D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.
- E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.
- F. Leak check and record ____________ atm-cc/sec.
  Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

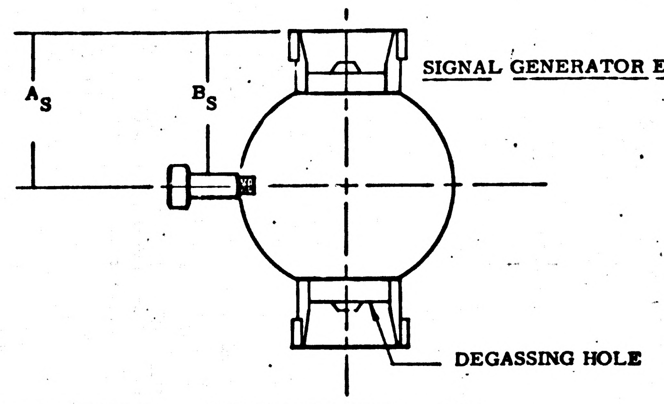
FLOAT MEASUREMENTS

TORQUE GENERATOP END



$\boxed{A_T} = \boxed{B_T} + .1250$

SIGNAL GENERATOR END



$\boxed{A_S} = \boxed{B_S} + 1250$

---

5. Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.

B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly

A. End Cap Assembly

1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.

2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.

3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.

4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

B. Thermistor Installation

1) Procure thermistor per 2021518.

2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)

3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation

A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:

A. K&D #100 round nose for spreading.
B. K&D #106 flat for staking eyelet to counterbore.
C. K&D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.

F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.

E. Repeat A through D for the second damping block.

10. Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing

A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_s in the support block A-118435.

Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

B. Carefully lower the float into the main housing, with the torque generator up, the B- facing the assembler and + SRA to the left.

C. Insert the dummy stop pin A-92284 into the + SRA balance port, and secure it with a locking screw.

D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer.

12. Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.

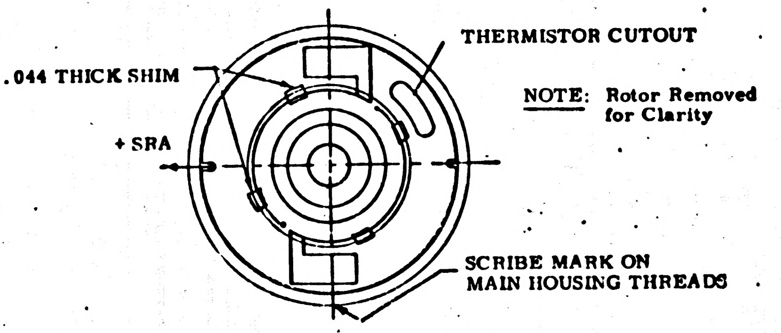
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

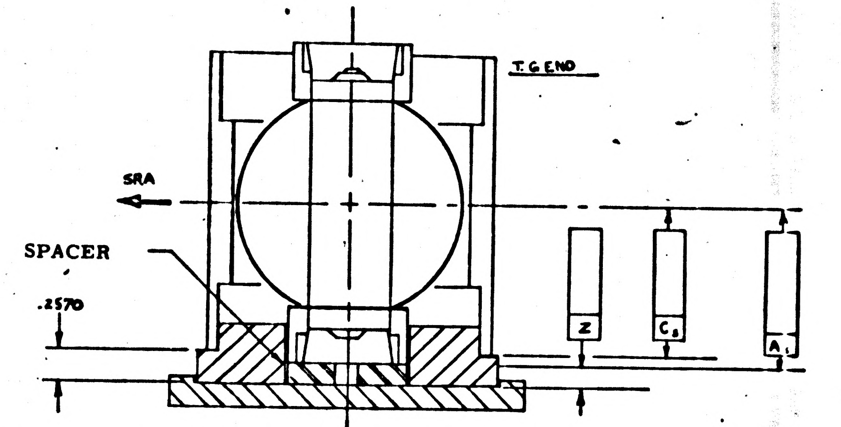
D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.

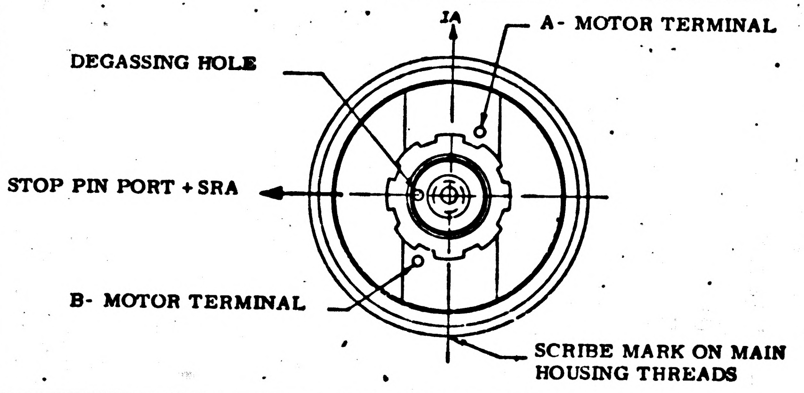

THERMISTOR CUTOUT
.044 THICK SHIM
+ SRA
NOTE: Rotor Removed for Clarity
SCRIBE MARK ON MAIN HOUSING THREADS



Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

$Z_s = 0.2570 + \boxed{C_3 \quad\quad} - \boxed{A_s \quad\quad}$

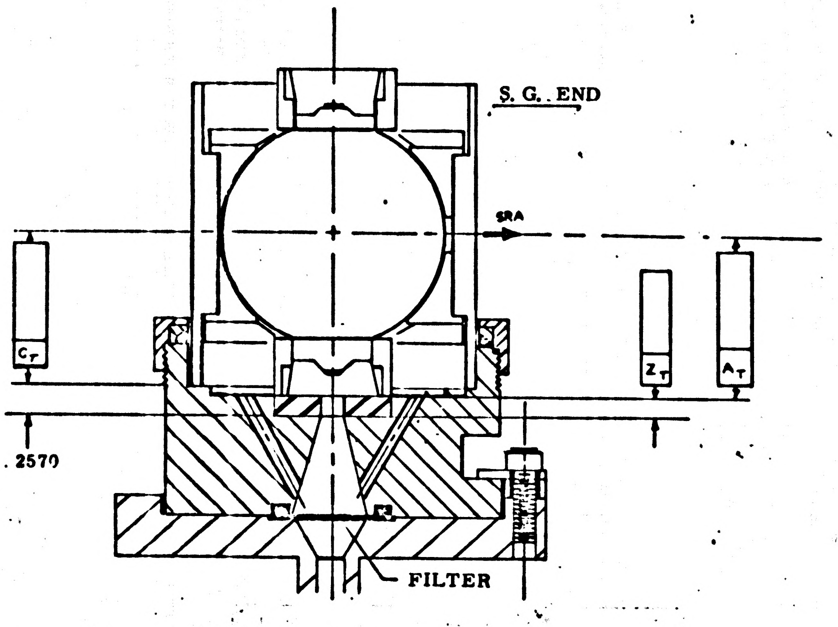


C 13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



$Z_T = 0.2570 + \boxed{C_T \quad\quad} - \boxed{A_T \quad\quad}$

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O. D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O. D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

E B H. Solder the flex leads to the float terminals as before.

C 14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 70 microinches.

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E. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

C 16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut. Omit this step if simulated + IA Balance Adjuster is used.

C 17. Dry Centering

A. Dry center the instrument as per MC 25-854.

C 18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 50 in-lbs. Invert unit and repeat above procedures.

D

C 19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page # 13.

Rev F 9-27-67

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CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964

MC 25-853

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OF 13

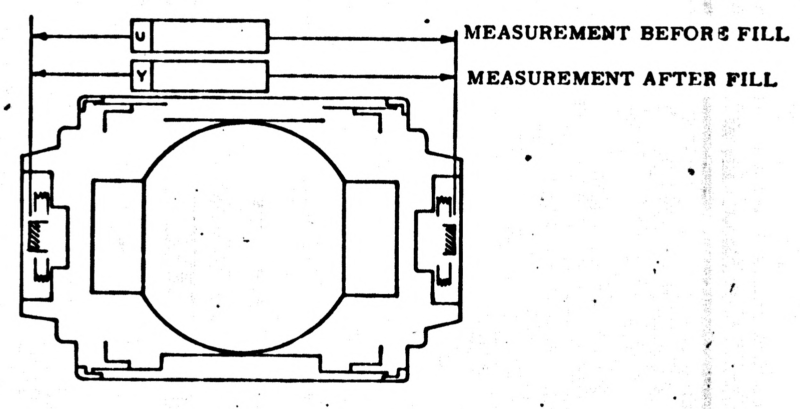
CB **20.** Bellows Measurement

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before ------- ☐
Shrouding

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)-- ☐ Grams

450

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CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64

MC# 25-853

SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_Y					
S_H TO S_L						T- TO T_Y					
S_L TO SSQ1 SEC						T_Y TO T_C					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT						
A- TO A+						
B- TO B+						
A- TO B-						
A+ TO B+						

451

APOLLO II IRIG Specification
MC 25-855 REV F
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
4-30-65	B	18829.	1, 4, 5	WJK.	
3/21/68	C	35603	4, 5	DRK	--
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8	DRK	--
1/31/69	E	37288	1-3	MGM EA	WLS
4/21/69	F	37524	3, 6	MGM EA	WLS

TP#11938

This MC specification consists of page i ~~to~~___and 1 to 7 inclusive.

FLOAT ASSEMBLY PROCEDURE

1. Wheel and float must be matched for .000025±.000015 interference.

2. Examine the inspection report accompanying the float and bring to the supervisor's attention any deviation from the print.

Record the O.D. of the wheel shaft. This information will be found in MC 25-605.

+SRA ________________ -SRA ________________

Record I.D. of hemisphere shaft bore

+SRA ________________ -SRA ________________

Average Interference

+SRA ________________ -SRA ________________

3. Lap the 12-72 and 5-40 balance weights, also the 2-56 sealing screw to insure a smooth fit. Extreme care should be taken with the 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305A lapping compound. With a dummy shaft #A-92245 lap the 5-40 threads of the bushings.

NOTE: Examine end stone and jewel for any residual adhesive. Residual adhesive may be removed with a .040 drill blank charged with 305A lapping compound.

4. Clean the #5-40 and #12-72 balance Weights, the two Bushings, the two Float Hemispheres, and the sealing screw by brushing them in clean trichloroethylene for a minimum of three (3) minutes. Ultrasonically rinse them in clean Freon for the same time period. Clean the Stator-Gimbal Assembly by brushing it in:

a. varsol #2 at 70 to 95°F or
b. trichloroethylene for a period not to exceed five (5) minutes at room temperature. Rinse the part in clean Freon.

NOTE: The Stator-Gimbal Assembly is not to be ultrasonically cleaned in this or any subsequent operations.

5. Weigh all the float parts and record information on sheet #6.

6. Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in Acetone followed by cleaning as in step #4.

7. Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8. Measure and record the following:

A) O.D. of stator ________________
B) I.D. of gimbal ________________

Subtract the gimbal I.D. from the stator O.D. and enter in "C".

C) Average interference ________________(.0001-.0003)

INSTRUMENTATION LABORATORY
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CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
DATE: Joseph Publicover

MC 25-855 REV E

SHEET 2
OF 7

9. Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ±10° for about five minutes.

B. Place the bushing A-92287 into the pressure plate.

C. Assemble the motor stator to the pressure plate A-87423.

D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O.D.

F. Remove the gimbal and fixture base from the hot plate.

G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the stator bottoms on the base.

A H. Remove fixture and check centering of the stator in the gimbal. Check continuity. To be centered to within .005".

A I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F oven and cure for 1 1/2 hours.

10. Weigh gimbal and record ________________ gms.

A 11. Grind I.D. of motor stator as per drawing 2021625.

12. After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol (room temperature or warm 90°F ± 5°F) followed a thorough rinsing in clean freon. Trichloroethylene may be used instead of varsol #2 if the exposure time to the solvent is less than five (5) minutes at room temperature.

13. Weigh gimbal and record ________________gms.
A Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet (sheet #6).

14. Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.
A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ± 5° oven for 1/2 hour.

B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O.D. two power leads and to the gimbal counter bores and insert the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal. Cure for one hour at 180°F.± 5°.

C. Repeat step "B" on opposite end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063 diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F ±5°F.

E. Remove from oven and fill the back side of the two remaining .063 diameter holes and cure for two hours at 180°F ±5°F.

15. Install .062 diameter ball and 2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10×10^{-8} ATM cc/sec. Leak rate ________________

16. Cycle the gimbal from 40°F to 180°F four times and releak check. Alt cycle: 32°F to 200°F at 4°/min. Maximum leak rate = 0.10×10^{-8} ATM cc/sec, with a dwell time of one (1) hour at the extremes. Leak rate ________________

17. Remove the sealing screw and .062 diameter ball from the degassing hole. Reassemble the #2-56 sealing screw to the gimbal. DO NOT TIGHTEN. Solder the four (4) power lead-ins to the motor stator terminals with 60-40 solder and 1571 Kester Flux. Clean the solder joints with acid brush and trichloroethylene, followed by rinsing in clean freon. Perform electrical check.

Alternate: AP-20 flux remover followed by trichloroethylene brushing and subsequent rinsing in freon may be used.

18. Assembly of wheel to float.

A. Thoroughly clean all the float parts, except the Inertial Element and Bearing Assembly, and the fixtures to be used by brushing them in clean filtered Freon.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on thermostatically controlled hot plate set to 350°F ±15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms.

NOTE: Nylon gloves or finger cots to be worn when handling wheel.

19. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

20. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

21. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F for approximately 15 minutes.

22. Heat the -SRA hemisphere as in "B" of step #17.

23. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

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MC 25-855
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24. Carefully assemble the wheel and +SRA hemisphere as in "C" of step #17. Immediately remove from hot plate and place assembly on steel or brass block and allow to cool.

25. Balancing the float in Air

A A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the blancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg of tape to achieve balance along SRA.

26. The float at this time is complete except for the rotors and balance weights. Weigh the float and record ________________ gms.

27. Mount the float on centers - fixture 2A3-10B186-2 and measure the runout of the stub shafts. T. I. R. should be no greater than .0002. Measure the runout of the sphere and record on sheet 7 Fig. 3.

B 28. Refer to MC 25-803 or MC 25-869 or MC 25-880 for instructions on setting the +SRA bushing.

B 29. Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ± 5°. oven for 45 minutes.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure on next page.

Rev. B 4-30-65 (Revised & Retyped)

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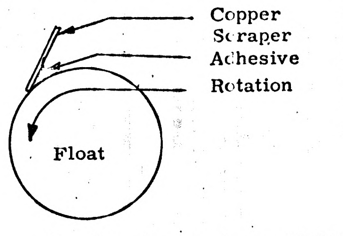

Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure of the completed float.

C. Cure for one hour at 175°F ± 5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ± 5°.

30. Filling the Float with Helium

A. Weigh the float, the 2-56 sealing screw and ball and record gms.

B. Place a 2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062 diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to 0" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive the ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw.

The following alternate procedure may be used:

Install float in fixture as described above. Draw a vacuum of 15" Hg and then admit helium to 0" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as above.

C. Weigh the float and record ________________.

D. Compare the weight of the float before and after filling and record the decrease in weight which should be approx. 18 mg. ____________gms.

31. Leak check and record ____________________atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 32. Cycle the float four times from 40°F to 180°F at an approximate rate of 3° per minute. Alt: Cycle: 32°F to 180°F at a rate of 4°/min. with a dwell time of one (1) hour at the extremes.

33. Leak check and record ____________________

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

A 34. Refer to MC 25-813 or MC 25-869 or MC 25-880 for float run-in requirements.

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PREPARED BY: J. Publicover
DATE: February 10, 1964
MC 25-855F
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FLOAT WEIGHT RECORD

Apollo II IRIG

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
2021513	4	Power Lead-in		.092	
2021634**	8	Balance Weight (Final Rot. Adj.)		.740	
2021635**	4	Balance Weight Spring		.018	
2021636	1	Centering Shim		.013	
2021631	2	Bushing		1.676	
2021528	1	#2-56 Sealing Screw		.037	
2021532	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
2021627	2	Hemisphere		14.701	
2021628	1	Gimbal		26.051	
2021632	1	Motor Stator (Finish Ground)		18.300	
A 2021637	2	Rotor Assy. *		32.968	
2021701	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
2021633	As Req.	Weight Reserve for Flotation			
		Adjustment & Preliminary		1.198	
		Balancing			
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.
**Install at the 2021611 level of assembly for the 2021611-000 configuration________ only.

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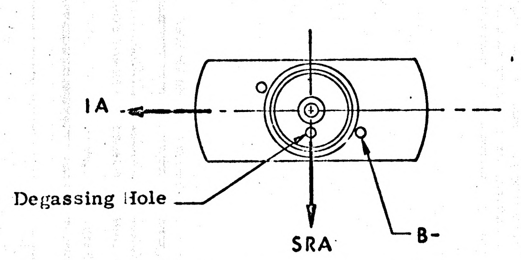
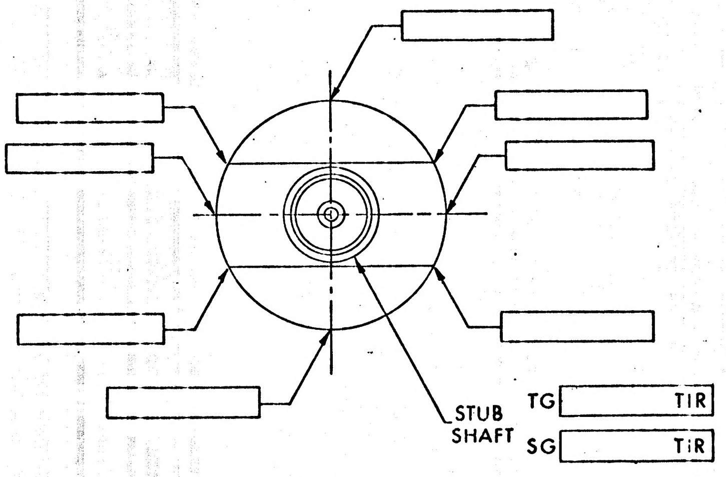


(View from T. G. End)



Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC -25-808F
Release Date Nov 1 1964
Release Revision Rev E
Class __________ Release
TDRR 14046

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
6-24-68	F	36405	1, 4		

This MC specification consists of page 1 to ___ and 1 to 4 inclusive.

TP#11938

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CAMBRIDGE, MASS.

PREPARED BY: Fred Straccia
DATE: August 25, 1961

TDRR 14046 NOV 4 1964
TDRR 36405 JUN 24 1968
MC 25-808F

SHEET 1 OF 4

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

1. Stator Core

E Heat treat laminations B-62045 (2021674) per MC #105. Remove all burrs and throughly clean laminations according to MC 25-900. Bond laminations using
B fixture #2B3-10B12 per MC 25-300. There are approximately 33 laminations to a stator core. Coat all surfaces except O. D. with Hi-Dielectric Enamel by
E American Durafilm Co. (2021539) (2 coats 0.005 max. thick.).

2. Winding

Lap wind core as follows:

56 turns per coil of #35 A. W. G. aluminum wire, heavy silicone coated (2021540) 4 pole, 2 phase, 3 coils per pole per phase, 1-5 throw 2/3 pitch. Lap wind starting with phase B in slots 1-5 2-6 3-7; then phase A in slots 4-8, 5-9, 6-10. The slots are numbered C. C. W. as viewed from the side the leads come out.

3. Inserting Slot Cell Paper

D After the second coil of A phase has been wound (5-9), there will be two coil sides in slot #5. Insert slot cell paper dwg. A-107247 (20221583) in slot #5 between winding and core. This is done by compressing the winding with a wedge-shaped wooden peg away from the slot opening on both sides of the core. Compress winding under slot opening by carefully pushing through a long pointed wooden peg between the winding and core. Insert the small end of slot cell paper in this space. Pull paper through from the opposite side until it fits snug. Cut paper on both sides as close to the core as possible. Paper should lie flat and extend equally on both sides of the slot opening.

Insert slot cell papers after each successive coil has been wound.

4. Location of Winding Leads

Looking at the finished-wound stator from the winding lead side (top side) and calling the slot having the first half turn of the first coil as slot #1, number the slots C. C. W. from 1 to 24. The four winding leads are identified

Rev. B 8/31/62
Rev. A 11/1/61
Rev. C 12/20/62
Rev. D 1/17/63
Rev. E 9/10/64

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as follows:

B+ Slot #1		B- Slot #21
A+ Slot #4		A- Slot #24

Check for continuity of each phase, for grounds in each phase, and for shorts between phases.

Position the winding leads as follows:

A+ to Slot #12 (bottom)	A- to Slot #24 (bottom)
B+ to Slot #16 (top)	B- to Slot #4 (top)

To bring B+ and B- to their respective slot positions, weave the leads through the winding so as to follow the winding pitch. Bring A+ to Slot #12 in the same manner and insert lead under slot cell paper. Position A- by removing one half turn and looping under coil. All winding leads should come out from the inside of the stator winding at the appropriate slot position.

Cut leads to 2" lengths and strip insulation with X-Var stripper down to about 1/4" from the top of the winding end turns. Clean stripped leads with Kimwipe (soft tissue) saturated with Denatured Ethyl Alcohol. Check for continuity, grounds, and shorts between phases.

5. Tin the four winding leads per MC 25-819.

6. Soldering Winding Leads to Terminal Leads

Use four 5" lengths of #35 A. W. G. H. F. copper wire for terminal leads. Strip, clean and tin 2" of each terminal lead. Insert terminal leads under slot cell papers at the appropriate positions so that they can be soldered to the winding leads. Pigtail the tinned portion of each winding and terminal lead. Solder pigtails using the tinning procedure of MC 25-819. Cut pigtails
E to 1/4" and insulate with Mylar tape or shrinkable sleeving per NASA cwg 1010490-120.

7. Forming (Forming Fixture A-87414)

Use a wedge-shaped wooden peg and carefully form the O. D. of the winding on both sides so that it will clear the I. D. of top and bottom plates of forming fixture. Assemble stator to plates. Visually check assembly for pinched wires.

Form I. D. of stator on both sides so that it will clear O. D. of upper and lower supports. Assemble supports to stator and check for pinched wires. Lay the terminal leads on the top of the stator winding. Assemble forming

---

fixture. Check for continuity, grounds and shorts between phases.

8. Connecting (Terminal Pins to Terminal Leads)

Strip, clean and tin the four terminal leads down to about 1/8" from the top of the winding end turns.

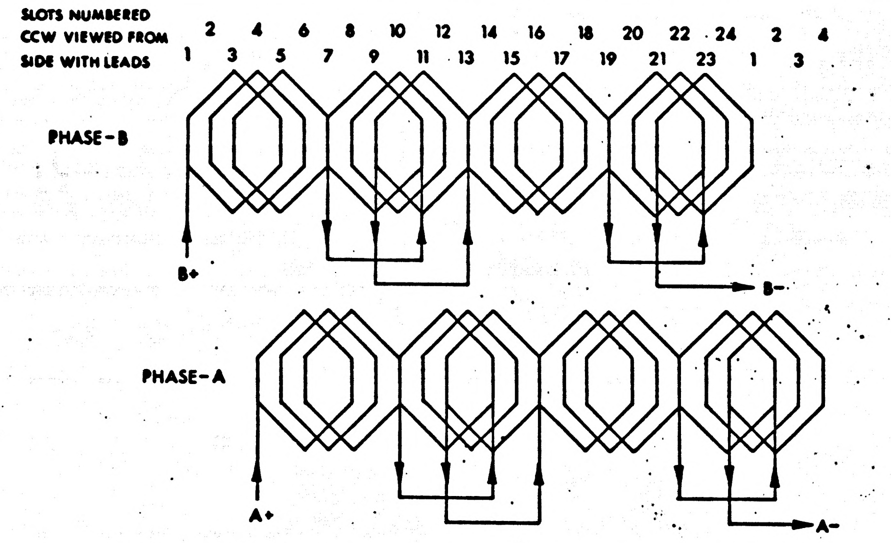
Clean the tinned terminal leads and four motor terminals with denatured ethyl alcohol.

E Hold terminal with a pair of tweezers and place a drop of Kester soldering Flux #1571 on top of terminal. Melt a small bead of 96.5 SN, 3.5 AG solder on soldering tip. Sweat solder into terminal hole until it is completely filled.

E C Place terminal insulator A-107246 (2021576) over terminal lead. Hold solder filled terminal with a pair of tweezers and sweat terminal down over the terminal lead to proper height. (Do not allow terminal to drop below the tinned portion of the terminal lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.

Check for continuity, grounds, and shorts between phases.

9. Assemble stator to potting mold per MC 25-504.


SLOTS NUMBERED
CCW VIEWED FROM
SIDE WITH LEADS
2 4 6 8 10 12 14 16 18 20 22 24 2 4
1 3 5 7 9 11 13 15 17 19 21 23 1 3
PHASE-B
B+
B-
PHASE-A
A+
A-

ARROWS INDICATE DIRECTION OF WINDING

WINDING PROCEDURE:

1. WIND FROM TWO SPOOLS USING ONE CONTINUOUS LENGTH OF WIRE FOR EACH PHASE.
2. LAP WIND, STARTING WITH PHASE B IN SLOTS 1-5, 2-6, 3-7, ETC. THEN PHASE A IN SLOTS 4-8, 5-9, 6-10, ETC.
3. EXCITATION PHASE ORDER A, B APPLIED TO TERMINALS A & B RESPECTIVELY WILL PRODUCE C.W. ROTATION FIELD, VIEWED FROM THE SIDE WITH LEADS
4. Nominal DC resistance per phase at room temperature= 67Ω.

4 - POLES
2 - PHASE
3 - COILS/POLE/PHASE
#35 - AWG HEAVY SILICONE COATED ALUMINUM WIRE
56 - TURNS/COIL
1-5 - COIL THROW
2/3 - PITCH

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PREPARED BY Fred Straccia
DATE: August 25, 1961

IDRR 36405 JUN 24 1968
MC 25-808 F

SHEET 4
OF 4

IL 27

APOLLO II IRIG Specification
~~ATP 2021300~~, MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531 -

Final Assembly Procedure for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13		
7-20-65	C	22893	5, 6, 7, 9, 10, 11, 12	WK	
10-8-65	D	23195	11, 12	WK.	N/A
1-12-65	E	25210	10	WK.	A. C. METZGER
-27-67	F	34995	10, 11	PRK	
2-16-68	G	35662	2, 7, 11	PRK	

This specification consists of pages 1 to 1 and 1 to 13 inclusive.

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PREPARED BY: David N. Kupelian
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DATE: February 26, 1964

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Rev B 12/21/64
Rev A Revised and Rewritten 10-24-64

Final Assembly Procedure for Apollo II IRIG

General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean.

1. Sub-Assemblies and Parts to be Demagnetized
   A. All magnetic parts prior to final assembly.
   B. Float Assembly, Dwg. 2021619.
   C. End housing assemblies, Dwg. 2021663 and 2021649.
2. Float Preparation
   A. Cementing the rotors to the stub shaft.
      1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
      2) Assemble the rotors to the float to insure proper seating.
      3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
      4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
      5) TG rotor should be aligned per MC 25-618 step A, 11.
      6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
      7) Place assembly in oven and cure for 1-1/2 hours minimum at 150° ± 5°F.
      8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

TG End ______ TIR
SG End ______ TIR

Maximum allowable runout on either end 0.0005 TIR.

3. Float Measurements
   A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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4. Flotation
   A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

Weigh the float and record ______ gm.

   B. Determine the neutral buoyancy, end for end and rotational balance as follows:
      1) Place the float in an oven at 135° ± 5°F for 15 minutes minimum.
      2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
      3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
      4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

B Weight in air of solder on holder at TG end ______.
B Weight in air of solder on holder at SG end ______.

Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

Weight (in air) added to TG end ______
Material ______
Weight (in air) added to SG end ______
Material ______
Total float weight in air ______

      5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

   C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Rev. G 2-16-68

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Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

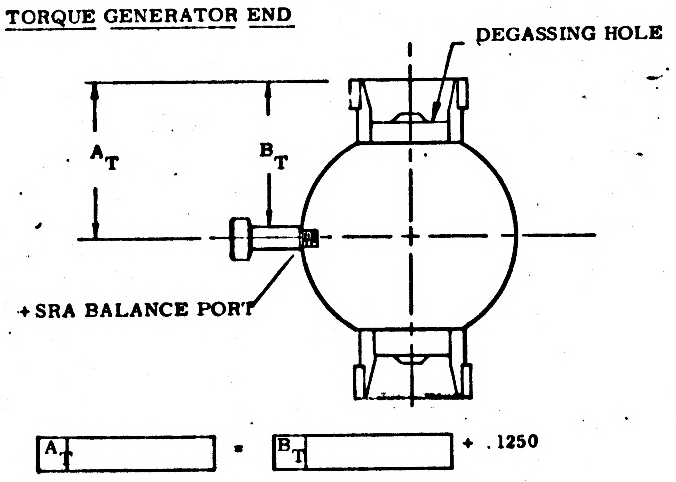
To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

NOTE: Plummets may be used to check fluid density while performing flotation.

   D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.
   E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.
   F. Leak check and record ______ atm-cc/sec.
      Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

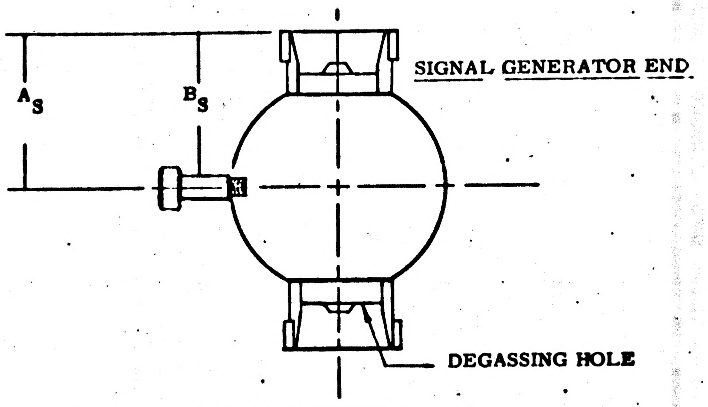
FLOAT MEASUREMENTS

TORQUE GENERATOR END



A_T = B_T + .1250

SIGNAL GENERATOR END



A_S = B_S + 1250

AA2

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5. Main Housing Preparation
   - A. Lap the balance adjuster locking screws and the 00-96×5/32 long screws using 305A lapping compound.
   - B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly
   - A. End Cap Assembly
     - 1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.
     - 2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.
     - 3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.
     - 4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

B

   - B. Thermistor Installation
     - 1) Procure thermistor per 2021518.
     - 2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)
     - 3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

C

7. Damping Block Assembly Preparation
   - A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.
   - B. Check the fit of the damping blocks to the main housing.
   - C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:
     - A. K&D #100 round nose for spreading.
     - B. K&D #106 flat for staking eyelet to counterbore.
     - C. K&D #108 flat for staking eyelet head.

- D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.
- E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.
- F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.
- G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.
- H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation
   - A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.
   - B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring
   - A. Mount a damping block assembly to fixture B-92316.
   - B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.
   - C. Lay a piece of flat pegwood across the center of the flex lead.
   - D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.
   - E. Repeat A through D for the second damping block.

10. Air Gap Measurements
    - A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing
    - A. Select the correct spacers A-84086, 2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_s in the support block A-118435.

Rev. G 2-16-68

Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

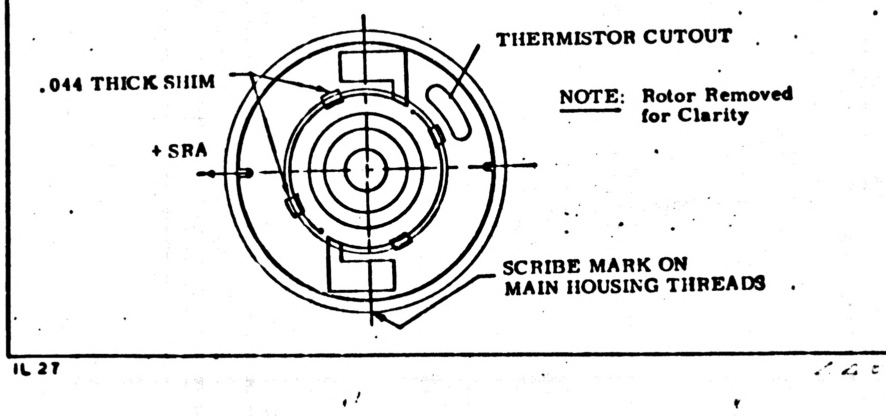
- B. Carefully lower the float into the main housing, with the torque generator up, the B-facing the assembler and + SRA to the left.
- C. Insert the dummy stop pin A-92284 into the +SRA balance port, and secure it with a locking screw.
- D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer. Tooling simulating the balance adjuster may be used instead of the actual hardware for purpose of assembly until dry centering has been accomplished.

C

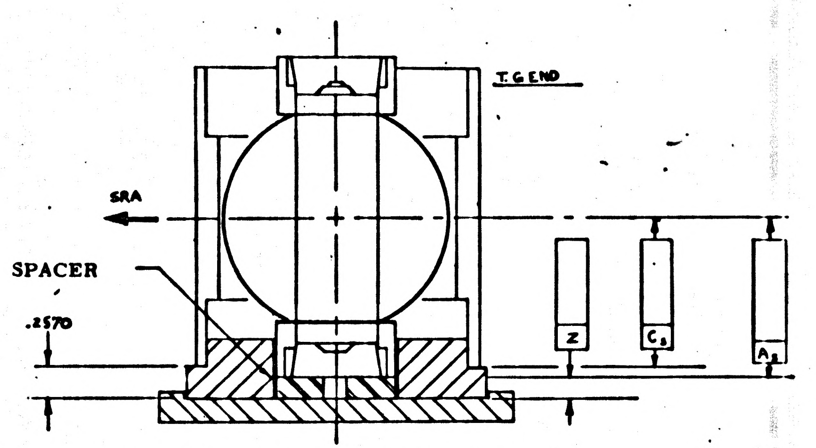
12. Torque Generator End Damping Block Assembly
    - A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.
    - B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.
    - C. Use the two shims A-87335 to support the weight of the flex lead as shown below.
    - D. Apply a small amount of #1571 Kester flux to each float terminal.
    - E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

    Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

    Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.



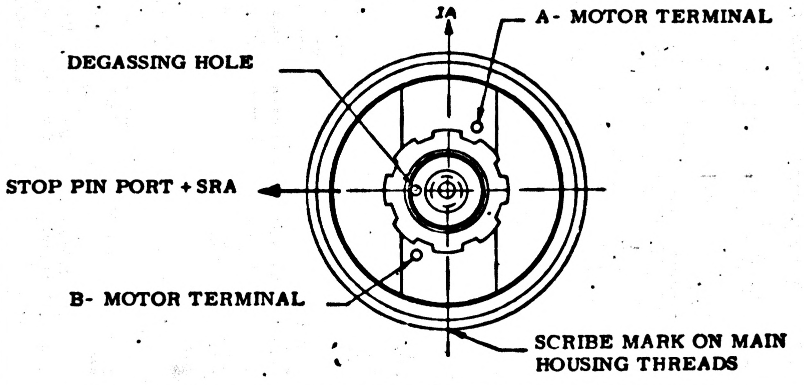
NOTE: Rotor Removed for Clarity



Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

Z_s = 0.2570 + $\boxed{C_3}$ ☐ - $\boxed{A_s}$ ☐

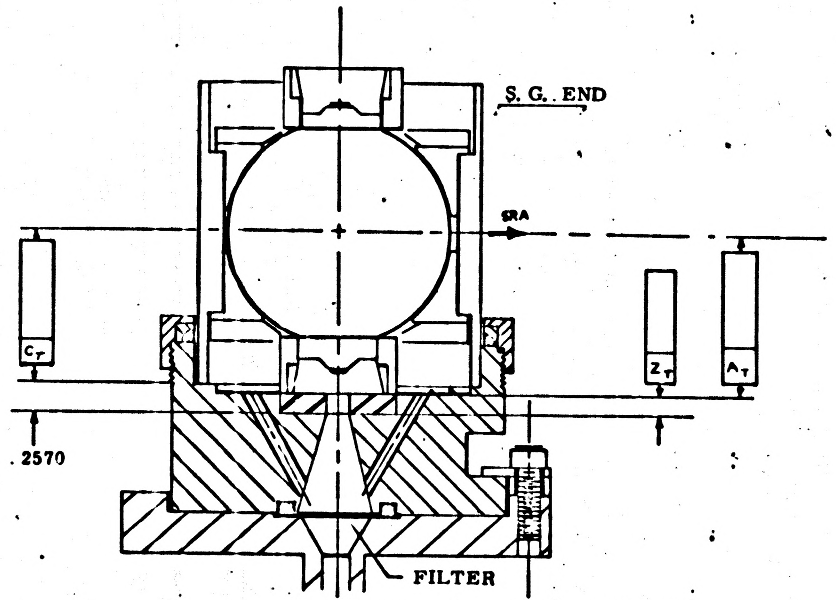


C 13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



Z_T = 0.2570 + $\boxed{C_T}$ ☐ - $\boxed{A_T}$ ☐

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O. D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O. D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

E B H. Solder the flex leads to the float terminals as before.

C 14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 70 microinches.

E. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

C 16. Assembly of Torque Generator End Housing

Rev. G 2-16-68

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut.

C 17. Dry Centering

A. Dry center the instrument as per MC 25-854.

C 18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end D cap clamp to 60 in-lbs. Invert unit and repeat above procedures.

C 19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page # 13.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964
MC 25-853
SHEET 12
OF 13

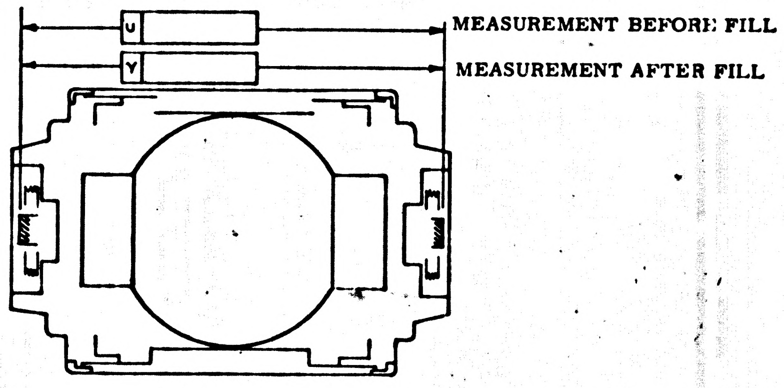
CB 20. Bellows Measurement

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding
Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)--- ☐ Grams

IL 27

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64
MC# 25-853
SHEET 13
OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_Y					
S_H TO S_L						T- TO T_Y					
S_L TO SSQ1 SEC						T_Y TO T_C					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT

A- TO A+						
B- TO B+						
A- TO B-						
A+ TO B+						

IL 27

APOLLO II IRIG Specification
MC 25-855
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4-30-65	B	18829	1, 4, 5	WK	
3/21/68	C	35603	4, 5	DRK	
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8	DRK	
1/31/69	E	37288	1-3	MGM EA	WLS
4/21/69	F	37524	3, 6	MGM EA	WLS
6/17/69	G	37671	All	MGM EA	MH

TP#11938

This MC specification consists of page i ~~to~~ ____ and 1 to 9 inclusive.

FLOAT ASSEMPLY PROCEDURE

Examine the inspection report accompanying the float, and bring to the supervisor's attention any deviation from the print.

The wheel shaft, and float hemispheres must be matched for a .000025" ± .000015" interference fit.

1.0 Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA ____________ -SRA ____________

Record the I. D. of the float hemisphere bores.

+SRA ____________ -SRA ____________

Average Interference

+SRA ____________ -SRA ____________

2.0 Lap the #12-72 and #5-40 balance weights, also the #2-56 sealing screw to insure a smooth fit. Extreme care should be taken with # 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305 A lapping compound. With a dummy shaft #A-92245 lap the #5-40 threads of the bushings. Refer to MC-400 for handling beryllium.

3.0 Carefully examine the jewel and end stone area under a microscope for any residual adhesive. This area can be cleaned using a .040" drill blank charged with #305 A lapping compound.

4.0 Clean all the float parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, followed by an ultrasonic rinse in

---

clean freon for the same time period.

5.0 Weigh all the float parts and record this information on the float weight sheet.

6.0 Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in acetone, followed by cleaning as in step #4.0.

7.0 Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8.0 Measure and record the following:
A) O. D. of stator ____________
B) I. D. of gimbal ____________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".
C) Average interference ____________ (.0001"-.0003")

9.0 Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ± 10° for about fives minutes.
B. Place the bushing A-92287 into the pressure plate.
C. Assemble the motor stator to the pressure plate A-87423.
D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O.D.
F. Remove the gimbal and fixture base from the hot plate.
G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the the stator bottoms on the base.
H. Remove fixture and check centering of the stator in the gimbal. Check continuity. (Stator should be centered to within .005")
I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F ±5° oven and cure for 1 1/2 hours minimum.

10.0 Weigh gimbal and record ____________ gms.
11.0 Grind I. D. of motor stator as per drawing 2021625.
12.0 After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol(room temperature or warm 90°F ± 5°) followed a thorough rinsing in clean freon.
13.0 Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.
14.0 Weigh gimbal and record ____________ gms.
Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet.
15.0 Power Lead Installation
A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ±5° oven for 1/2 hour minimum.
B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. of two power leads and to the gimbal counter bores and insert the the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal.

Cure for one hour at 180°F ± 5°.

C. Repeat step "B" on opposite end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063" diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F±5° minimum.

E. Remove from oven and fill the back side of the two remaining .063" diameter holes and cure for two hours at 180°F±5° minimum.

16.0 Install .062" diameter ball and #2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10×10^{-8} ATM cc/sec. Leak rate_______________.

17.0 Cycle the gimbal from 40°F to 180°F four (4) times, with a dwell time of one (1) hour at the extremes. Alternate cycle +32°F to +200°F four (4) times. Releak check the gimbal. Maximum allowable leak rate= 0.10×10^{-8} ATM cc/sec. Leak rate=_______________ATM cc/sec.

18.0 Remove the sealing screw and .062" diameter ball. Re-assemble the #2-56 sealing screw to the gimbal. Do not tighten.

19.0 Assembly of the Wheel to the Float

A. Thoroughly clean all the float parts, and fixtures to be used, in clean filtered freon. Follow by a thorough vacuuming.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on a thermostatically controlled hot plate set to 350°F +15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms. (Balancing numbers + SRA)
NOTE: Nylon gloves or clean finger cots to be worn when handling wheel.

D. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

E. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

F. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F±5° for approximately 15 minutes.

G. Heat the -SRA hemisphere as in "B" of step #19.

H. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

I. Carefully assemble the wheel and +SRA hemisphere down over the guide post until the wheel is bottomed into the -SRA bore, aligning the scribe marks as closely as possible. Allow to cool as in "D".

20.0 Balancing the float in air

A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the balancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg. of tape to achieve balance along SRA.

21.0 The float at this time is complete except for the rotors and balance weights. Weigh the float and record_______________gms.

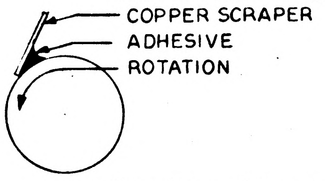
22.0 Mount the float on centers-fixture 2A3-10B186-2 and measure the runout of the stub shafts. T.I.R. should be no greater than .0002". Measure the runout of the sphere and record. Figure 3.

23.0 Refer to MC 25-803, MC 25-869, or MC 25-880 for setting compliance.

24.0 Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ±5° oven for 45 minutes minimum.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure 1.



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure and leak check.

C. Cure for one hour at 175°F ±5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ±5°.

25.0 Filling the Float with Helium

A. Weigh the float, the #2-56 sealing screw and ball and record.
_______________gms.

B. Place a #2-56 x 3/32 long S. S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062" diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to O" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive The ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw, using 25 to 30 in. oz of torque.

The following alternate procedure may be used:

Install float in fixture as described in "B". Draw a vacuum of 15" Hg and then admit helium to O" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as before.

C. Weigh the float and record _______________

D. Compare the weight of the float before and after filling and record the decrease in wieght which should be approximately 18 mg. _______________ gms.

26.0 Leak check and record _______________ atm-cc/sec.
Acceptable leak rate = 5×10^{-8} atm-cc/sec.

27.0 Cycle the float four (4) times from +40°F to +180°F at an approximate rate of 3°/minute, with a dwell time of one (1) hour at the extremes. Alternate cycle at +32°F to +180°F at a rate of 4°/minute.

28.0 Leak check and record __________ ATM-cc/sec.
Maximum allowable leak rate = 5×10^{-8} ATM-cc/sec.

29.0 Refer to MC 25-803, MC 25-869, or MC 25-880 for float run-in procedure.

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CAMBRIDGE, MASS.

PREPARED BY: J. Publicover
DATE: February 10, 1964

FLOAT WEIGHT RECORD
Apollo II IRIG
(FOR REFERENCE ONLY)

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
2021513	4	Power Lead-in		.092	
2021634	8	Balance Weight (Final Rot. Adj.)		.740	
2021535	4	Balance Weight Spring		.013	
2021636	2	Centering Shim		.013	
2021631	2	Bushing		1.676	
2021526	1	#2-56 Sealing Screw		.037	
2021532	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
2021627	2	Hemisphere		14.701	
2021628	1	Gimbal		26.051	
2021632	1	Motor Stator (Finish Ground)		18.800	
2021637	2	Rotor Assy.*		32.968	
2021701	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
2021633	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.193	
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.

A

16

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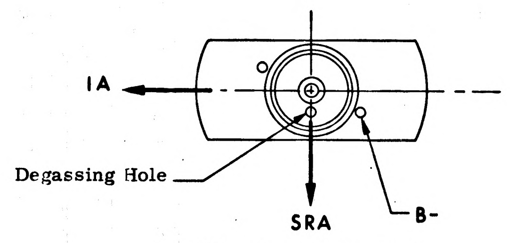
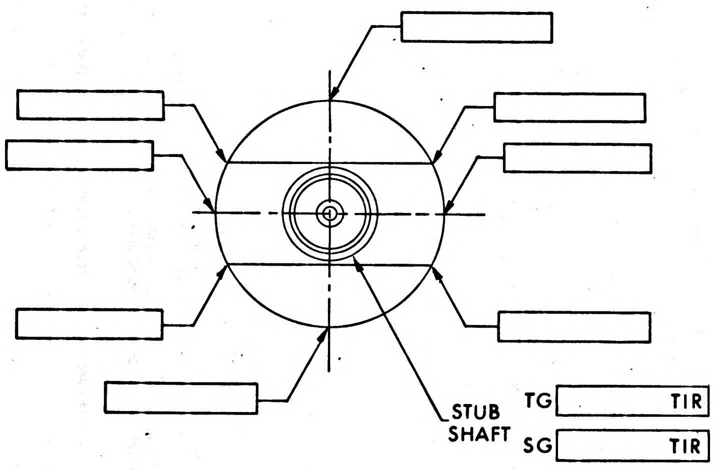
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Clifford J. Cormier
Joseph Publicover
DATE:



(View from T. G. End)



Runout of float sphere to pivots.

17

APOLLO II IRIG Specification
MC 25-816G
Release Date Nov. 18, 1964
Release Revision E
Class A Release
TDRR 14363

Title: FILLING PROCEDURE (Refer to Drawing 2A3-10D130)

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/2/68	F	35559	--	P.K.(1.)	
5/8/68	G	36401	1, 2	PRK	

TP#11938

This MC specification consists of page 1
to____and 1 to 9 inclusive.

FILLING PROCEDURE
(Refer to Drawing # 2A3-10D130)

1. Sub-Assembly of Unit Mount
    1. Clean all parts in accordance with MC 904.
    2. Place sleeve (2A3-10A130.50) on table with slotted end down.
    3. Place "O" ring on tip of bottom plate and place bottom plate (2A3-10A130.3) on sleeve and fasten with two # 1/4-20 slotted head screws.
    4. Place # 3-56 set screw and .078" ball into spotface provided in bottom plate.
    5. Place filter mesh and filter ring 2A3-10A130.11 into bottom plate.
    6. Place "O" ring in groove in bottom plate.
    7. Fasten guide plate 2A3-10A130.4 to bottom plate with three #10-32 slotted head screws.
    8. Reverse assembly after placing "O" ring in groove in guide plate
    9. Being certain aluminum ball and set screw are removed from bellows assembly, assemble spacer 2A3-10A130.8 onto bellows clamp 2A3-10A130.1 and thread assembly onto bellows until spacer contacts top of bellows.
    10. Thread nut 2A3-10A130.49 onto bellows clamp while holding spacer firmly with other hand to prevent clamp from turning, until nut contacts top of spacer.
    11. Still holding spacer firmly, turn nut clockwise 3 turns. This will place bellows in 135°F cap off position.
    12. Reverse unit and repeat for other end.
    13. Two options may be followed for sealing the unit after fill. If option (a) is to be used, perform step 13-a section 1 and steps 9-a and 10-a of section VI. If option (b) is to be used, perform step 13b of section 1 and steps 9b and 10b of section VI.

    13-a Solder two 12 inch leads to two connector barrels. Assemble the two connector barrels to the thermistor pins on the S.G. end housing. Carefully lower the unit into the sleeve (with thermistor connectors up) and down onto top of bottom plate.

    13-b Lower the unit into the sleeve and onto the top of bottom plate.

---

14. Put "O" ring on top of bottom plate and place top plate onto unit. Clamp with two # 1/4-20 slotted head screws.
15. Place #3-56 set screw and .078" ball into hole provided in top plate.
16. Place "O" ring in groove provided in top plate.
17. Fasten overflow reservoir to top plate with three #10-32 slotted head screws.
18. Place a glass cover on the overflow cup.

2. Fixture Assembly
    1. Lubricate the "L" gasket (2A3-10x130.20) with vacuum grease (Dow Corning) or BFC Fluid, and place it in position on the bell jar. This is best done by placing the bell jar in a horizontal position stretching the gasket entirely over the outside of the bell jar, and then slipping it over the end.
    2. Assemble the freshly cleaned (see MC 904) parts of the filling apparatus as shown in drawing 2A3-10D130. Clamp gyro subassembly on as shown with three #10-32 socket head screws.
    3. Place heaters and thermometers in upper block as shown. Set bell jar on the pump plate and cover with its guard.
3. Pumpdown
    1. Open M valve. Close V valve. Start pump. The main system must be tight enough to obtain 5-15 microns with pump on.
    2. Turn on lower and reservoir variacs and set them to achieve a temperature of 170°F. Watch the thermometers and adjust the voltage until the temperatures stabilize at 170° ± 5°F.
4. Degassing of Fluid Charge
    1. At about 38 hours of unit pumpdown, pour about 80 cc of 2400/137/2.385 Flotation Fluid (SCD 2021512) heated to about 165°F into a 150 ml. beaker. Fill the Buchner Funnel #1A3-10B129.18 by vacuum applied to the filter end while the cone end is held under the fluid surface in the beaker. Keep the flask heated to 160-170°F and apply a vacuum of 12 mm using degassing fixture 2A3-10C188. Degas until a vacuum of 12 mm can be maintained without over frothing. This operation will take approximately 45 minutes to 1 hour. Keep the fluid under vacuum with heat off until remainder of equipment is ready.
    2. After 40 hours slowly vent the system to atmosphere, remove the bell jar and place the degassed fluid in the upper block.

Replace bell jar with M and F valves open V valve closed start pumpdown. Close "F" valve at 12 mm on vacuum gage. Maintain funnel vacuum between 12-14 mm by operating "F" valve. Rest of system should pumpdown to 5-15 microns in one hour. Maintain bell jar pressure at 5-15 microns for a minimum of one hour prior to filling.

5. Filling
    1. Start fill when the upper block temperature reaches 200°F ± 10°F.
    2. Stop the pump, connect Freon Backfill Reservoir #B-100761 to vent as shown on sheet 6. Raise the bell jar pressure to 16 mm* by carefully cracking the "V" valve. Close "M" valve. Remove Freon Backfill Reservoir.

       *When vacuum gage is independent of gas composition, raise bell jar pressure to 11-13 mm.
    3. Open the "F" valve and crack the "V" valve until Bourdon gage reads 5-10" of vacuum. Close "F" valve.
    4. Control the flow rate into the "L" tube to about 25-30 drops per minute, by varying the vacuum in the funnel.
    5. When the fluid begins to enter the instrument, reduce the rate of fluid flow to approximately 16 drops per minute. This rate should be varied as necessary to complete filling in 1 to 2 1/2 hours.
    6. When the fluid shows in the overflow cup, increase the flow rate and fill up the "L" tube. Continue the flush until there is 1/4" to 1/2" of fluid in the cup.
    7. When step 6 is completed turn off heaters and vent both bell jar and funnel to atmosphere by opening F valve, and M valve and opening V valve slowly so that the return to atmospheric pressure should take no less than two minutes. Remove guard and bell jar.
6. To Seal
    1. Place 1/4" dia. steel ball in overflow reservoir.
    2. Remove heaters and thermometers from overflow reservoir.
    3. Remove three screws and slide overflow reservoir from top plate onto clean aluminum plate.
    4. Seal upper end of unit with .078 dia. aluminum ball and #3-56 set screw.

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PREPARED BY: C. Cormier
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5. Remove large "O" ring from top plate.

6. Remove three screws holding guide plate to mounting block and slide gyro unit assembly from mounting block onto clean aluminum block.

7. Invert gyro with guide plate up. Remove large "O" ring from the guide plate and remove a small amount of fluid with eye dropper to insure proper fit of "O" ring on piston.

8. Lower assembled weight #2A3-10A130.5 and handle #2A3-10A130.9 (previously heated to 160°F.) onto guide plate. Lower weight #2A3-10A130.58 over handle. Press gently by hand several times with about one pound pressure to seat the O-ring and insure free piston motion. Leave on for 40 hours minimum at 160°F ± 5°F. Total weight should be approximately 15 pounds to give 150 psi.

9-a Remove from oven, connect the two thermistor leads to a ruge bridge or equivalent. While the unit is cooling, remove the three screws holding the guide plate to the bottom plate and slide the guide plate and weight from the bottom plate.

9-b Remove from oven. Allow the unit to stabilize at 135°F ±2°. Hold at 135° ± 2°F for a minimum of 30 minutes before sealing. To seal this end, remove the three screws holding the guide plate to bottom plate and slide the guide plate and weight from bottom plate.

10-a When the thermistor reaches 135°F resistance, seal the unit with the .078" aluminum ball and #3-56 sealing screw.

10-b Remove filter plate and filter ring from the bottom plate and seal with .078" diameter aluminum ball and #3-56 set screw.

11. Quickly remove the two screws holding bottom plate to sleeve and remove bottom plate. Loosen bellows clamp. Withdraw unit from sleeve and loosen other bellows clamp.

12. Using parts 4, 5, and 6 of bellows seal assembly 2A3-10B138, re-establish the torque on each seal to 50 inch-pounds.
Note: Remove residual fill fluid in the bellows area by flushing a number of times with trichloroethylene and an eye dropper. Repeat using clean freon.

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13. Store in oven at 135± 5°F.

14. Weigh and record filled weigh (MC 25-853)

15. Measure and record bellows overall length (MC 25-853)

16. Unit now ready for thermistor calibration (MC 25-800).

17. After thermistor calibration shroud the unit per MC 25-852.

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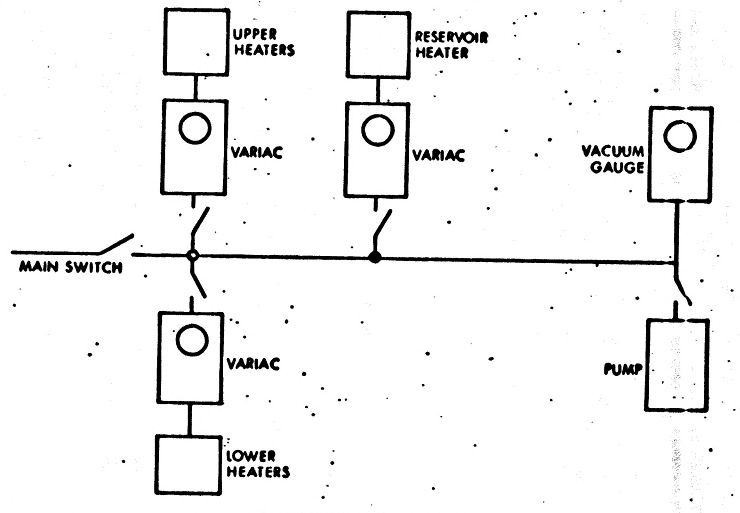
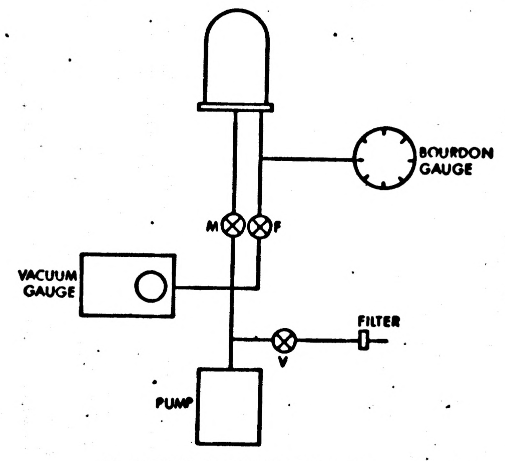


a) ELECTRICAL SCHEMATIC



b) VACUUM PLUMBING SCHEMATIC

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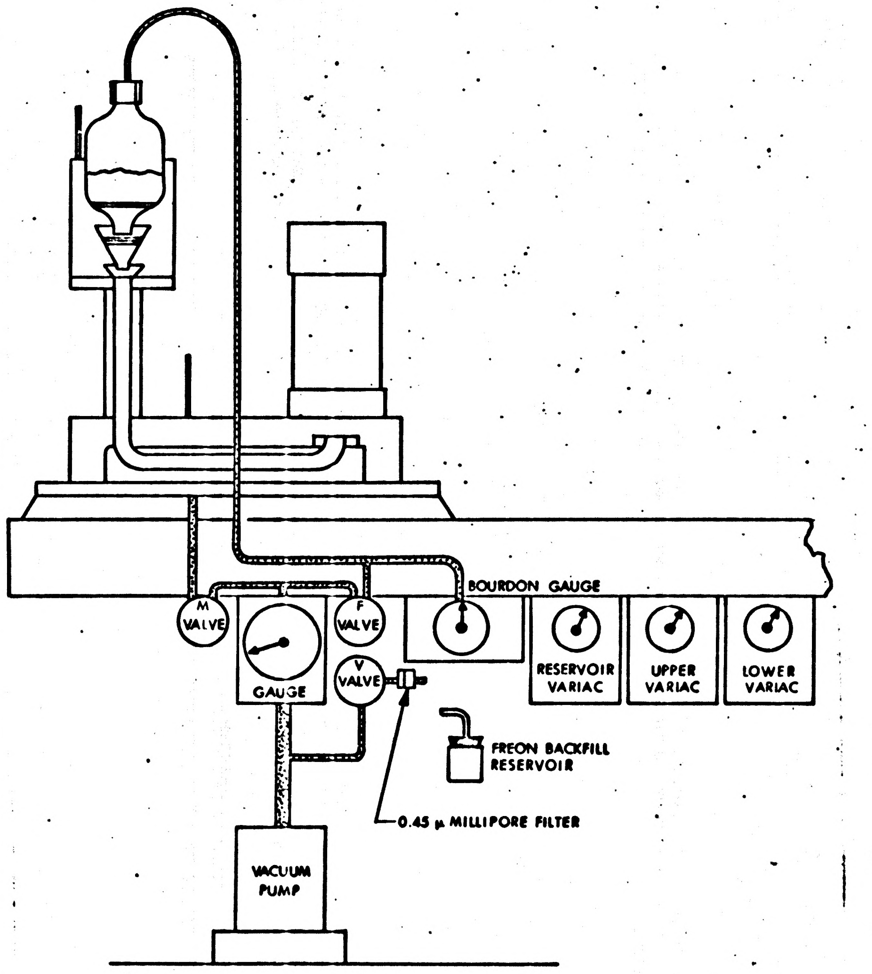

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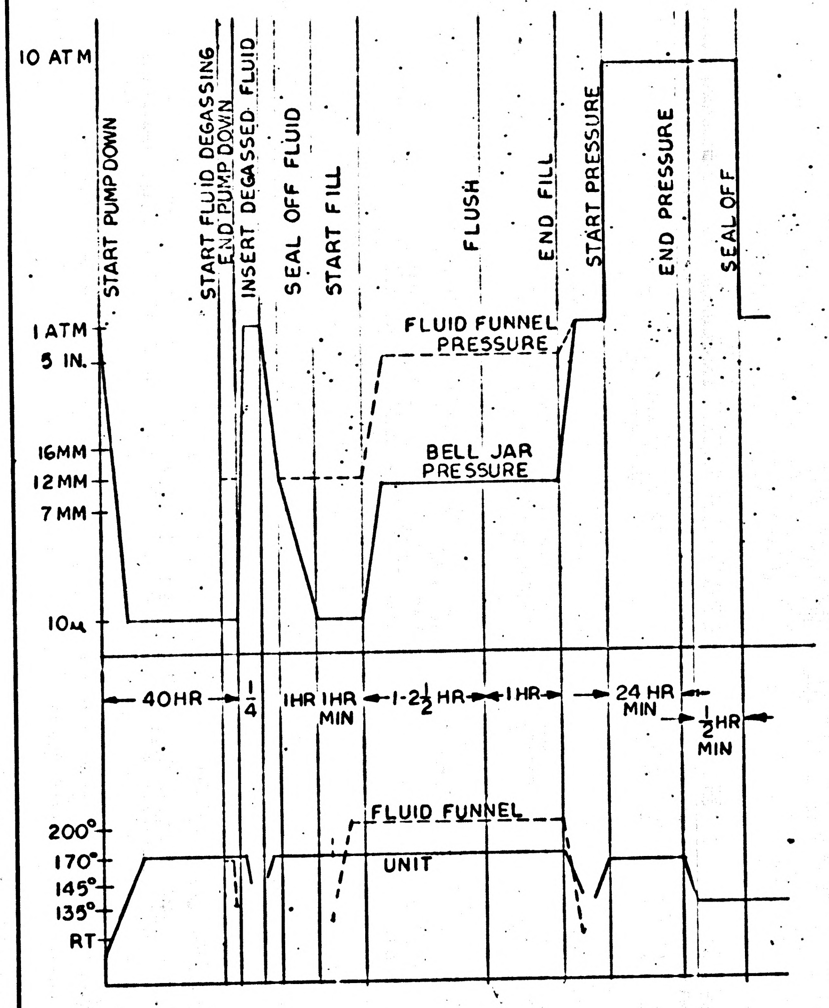
OF 9


10 ATM
1 ATM
5 IN.
16MM
12MM
7MM
10μ
200°
170°
145°
135°
RT
START PUMP DOWN
START FLUID DEGASSING
END PUMP DOWN
INSERT DEGASSED FLUID
SEAL OFF FLUID
START FILL
FLUSH
END FILL
START PRESSURE
END PRESSURE
SEAL OFF
FLUID FUNNEL PRESSURE
BELL JAR PRESSURE
40HR
1/4
1HR
1HR MIN
1-2½ HR
1HR
24 HR MIN
½HR MIN
FLUID FUNNEL
UNIT

IL 27

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PREPARED BY: C. Cormier
DATE: April 16, 1968

M.C. 25-816

Batch No.
Dens.
Vis.

SHEET 9
OF 9

REMARKS																		
METER VOLTS	U																	
	R																	
	L																	
TEMPERATURE	U																	
	R																	
	L																	
BELL JAR PRESSURE	μ																	
LIQUID PRESSURE	mm																	
ELAPSED																		
TIME																		
DATE																		

TP# 7427

IL 27

TDRR 14363 NOV 18 1964

APOLLO II IRIG Specification
MC -25-808
Release Date Nov 1 1964
Release Revision Rev E
Class ________ Release
TDRR 14046

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
6-24-68	F	36405	1, 4	PRK-78	
1/21/69	G	37218	3	MGM EA	WLS

TP#11938

This MC specification consists of page 1 to ____ and 1 to 4 inclusive.

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CAMBRIDGE, MASS.
TDRR 14046 NOV 4 1964

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808
SHEET 1 OF 4

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

1. Stator Core

E Heat treat laminations B-62045 (2021674) per MC #105. Remove all burrs and throughly clean laminations according to MC 25-900. Bond laminations using
B fixture #2B3-10B12 per MC 25-300. There are approximately 33 laminations to a stator core. Coat all surfaces except O.D. with Hi-Dielectric Enamel by
E American Durafilm Co. (2021539) (2 coats 0.005 max. thick.).

2. Winding

Lap wind core as follows:

56 turns per coil of #35 A.W.G. aluminum wire, heavy silicone coated (2021540) 4 pole; 2 phase, 3 coils per pole per phase, 1-5 throw 2/3 pitch. Lap wind starting with phase B in slots 1-5 2-6 3-7; then phase A in slots 4-8, 5-9, 6-10. The slots are numbered C.C.W. as viewed from the side the leads come out.

3. Inserting Slot Cell Paper

D After the second coil of A phase has been wound (5-9), there will be two coil sides in slot #5. Insert slot cell paper dwg. A-107247 (20221583) in slot #5 between winding and core. This is done by compressing the winding with a wedge-shaped wooden peg away from the slot opening on both sides of the core. Compress winding under slot opening by carefully pushing through a long pointed wooden peg between the winding and core. Insert the small end of slot cell paper in this space. Pull paper through from the opposite side until it fits snug. Cut paper on both sides as close to the core as possible. Paper should lie flat and extend equally on both sides of the slot opening.

Insert slot cell papers after each successive coil has been wound.

4. Location of Winding Leads

Looking at the finished-wound stator from the winding lead side (top side) and calling the slot having the first half turn of the first coil as slot #1, number the slots C.C.W. from 1 to 24. The four winding leads are identified

Rev. D 1/17/63
Rev. E 9/10/64
Rev. B 8/31/62
Rev. A 11/1/61
Rev. C 12/20/62

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as follows:

B+ Slot #1	B- Slot #21
A+ Slot #4	A- Slot #24

Check for continuity of each phase, for grounds in each phase, and for shorts between phases.

Position the winding leads as follows:

A+ to Slot #12 (bottom)	A- to Slot #24 (bottom)
B+ to Slot #16 (top)	B- to Slot #4 (top)

To bring B+ and B- to their respective slot positions, weave the leads through the winding so as to follow the winding pitch. Bring A+ to Slot #12 in the same manner and insert lead under slot cell paper. Position A- by removing one half turn and looping under coil. All winding leads should come out from the inside of the stator winding at the appropriate slot position.

Cut leads to 2" lengths and strip insulation with X-Var stripper down to about 1/4" from the top of the winding end turns. Clean stripped leads with Kimwipe (soft tissue) saturated with Denatured Ethyl Alcohol. Check for continuity, grounds, and shorts between phases.

5. Tin the four winding leads per MC 25-819.

6. Soldering Winding Leads to Terminal Leads

Use four 5" lengths of #35 A.W.G. H.F. copper wire for terminal leads. Strip, clean and tin 2" of each terminal lead. Insert terminal leads under slot cell papers at the appropriate positions so that they can be soldered to the winding leads. Pigtail the tinned portion of each winding and terminal lead. Solder pigtails using the tinning procedure of MC 25-819. Cut pigtails
E to 1/4" and insulate with Mylar tape or shrinkable sleeving per NASA dwg 1010-90-120.

7. Forming (Forming Fixture A-87414)

Use a wedge-shaped wooden peg and carefully form the O.D. of the winding on both sides so that it will clear the I.D. of top and bottom plates of forming fixture. Assemble stator to plates. Visually check assembly for pinched wires.

Form I.D. of stator on both sides so that it will clear O.D. of upper and lower supports. Assemble supports to stator and check for pinched wires. Lay the terminal leads on the top of the stator winding. Assemble forming

---

fixture. Check for continuity, grounds and shorts between phases.

8. Connecting (Terminal Pins to Terminal Leads)

Strip, clean and tin the four terminal leads down to about 1/8" from the top of the winding end turns.

Clean the tinned terminal leads and four motor terminals with denatured ethyl alcohol.

E Hold terminal with a pair of tweezers and place a drop of Kester soldering Flux #1571 on top of terminal. Melt a small bead of 96.5 SN, 3.5 AG solder on soldering tip. Sweat solder into terminal hole until it is completely filled.

E C Place terminal insulator A-107246 (2021576) over terminal lead. Hold solder filled terminal with a pair of tweezers and sweat terminal down over the terminal lead to proper height. (Do not allow terminal to drop below the tinned portion of the terminal lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.

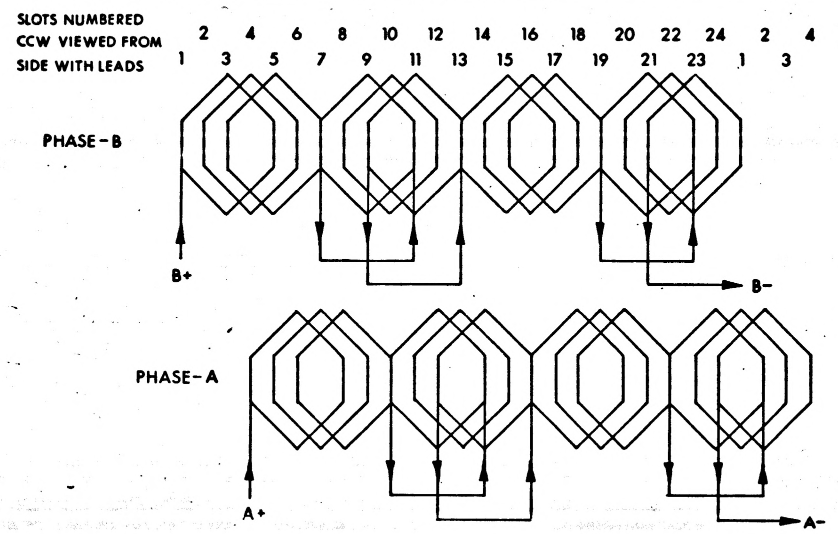
Check for continuity, grounds, and shorts between phases.

9. Potting Procedure: o potting mold per MC 25-504.

9.1 For 2021632-000 and 2021632-011 assemble stator to potting mold per MC 25-504.

9.2 For 2021632-021 assemble stator to potting mold per MC 25-913.

IL 27


SLOTS NUMBERED
CCW VIEWED FROM
SIDE WITH LEADS
2 4 6 8 10 12 14 16 18 20 22 24 2 4
1 3 5 7 9 11 13 15 17 19 21 23 1 3
PHASE-B
B+
B-
PHASE-A
A+
A-

ARROWS INDICATE DIRECTION OF WINDING

WINDING PROCEDURE:

1. WIND FROM TWO SPOOLS USING ONE CONTINUOUS LENGTH OF WIRE FOR EACH PHASE.
2. LAP WIND, STARTING WITH PHASE B IN SLOTS 1-5, 2-6, 3-7, ETC. THEN PHASE A IN SLOTS 4-8, 5-9, 6-10, ETC.
3. EXCITATION PHASE ORDER A, B APPLIED TO TERMINALS A & B RESPECTIVELY WILL PRODUCE C.W. ROTATION FIELD, VIEWED FROM THE SIDE WITH LEADS
4. Nominal DC resistance per phase at room temperature= 67Ω

4 - POLES
2 - PHASE
3 - COILS/POLE/PHASE
#35 - AWG HEAVY SILICONE COATED ALUMINUM WIRE
56 - TURNS/COIL
1-5 - COIL THROW
2/3- PITCH

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CAMBRIDGE, MASS.

PREPARED BY Fred Straccia

DATE: August 25, 1961

MC 25-808

SHEET 4
OF 4

APOLLO II IRIG Specification
~~ATP 2021500~~, MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13		
-20-65	C	22893	5, 6, 7, 9, 10, 11, 12	WK	
10-8-65	D	23195	11, 12	WK	N/A
1-12-65	E	25210	10	WK.	A. C. METZGER
9-27-67	F	34995	10, 11	PRK	
2-16-68	G	35662	2, 7, 11	PRK	
2-20-68	H	35689	1	PRK (13)	

This specification consists of pages i to ____ and 1 to 13 inclusive.

Final Assembly Procedure for Apollo II IRIG
General Preparation

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean. All turn-around subassemblies and parts previously exposed to BFC damping fluid shall be cleaned per ATP 2021500, MC 25-902.

Rev B 12/21/64
Rev A Revised and Rewritten 10-24-61
H Revised 2/21/68

1. **Sub-Assemblies and Parts to be Demagnetized**
   A. All magnetic parts prior to final assembly.
   B. Float Assembly, Dwg. 2021619.
   C. End housing assemblies, Dwg. 2021663 and 2021649.

2. **Float Preparation**
   A. Cementing the rotors to the stub shaft.
      1) Screw the carbide pivot 2A3-10A113.2 into one of the 12-72 balance ports.
      2) Assemble the rotors to the float to insure proper seating.
      3) Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.
      4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
      5) TG rotor should be aligned per MC 25-618 step A, 11.
      6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.
      7) Place assembly in oven and cure for 1-1/2 hours minimum at 150°± 5°F.
      8) Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record.

      TG End ____________ TIR
      SG End ____________ TIR

      Maximum allowable runout on either end 0.0005 TIR.

3. **Float Measurements**
   A. Insert reference pin 2A3-10A124.3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

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4. **Flotation**
   A. Assemble the 12-72 balance weights and springs to the float and at each port, determine the number of turns available and set the weights at the mid-position.

      Weigh the float and record ____________ gm.

   B. Determine the neutral buoyancy, end for end and rotational balance as follows:
      1) Place the float in an oven at 135° ± 5°F for 15 minutes minimum.
      2) Fill the flotation tank 2A3-10C165.1 with flotation fluid MC 25-614.
      3) Adjust the temperature of the tank to achieve 2.385 g/cc density.
      4) Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 10 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

         Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.

B Weight in air of solder on holder at TG end ____________.
B Weight in air of solder on holder at SG end ____________.

Compute the effective weight of the solder in the fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

Weight (in air) added to TG end ____________.
Material ____________.
Weight (in air) added to SG end ____________.
Material ____________.
Total float weight in air ____________.

      5) Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

         Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

   C. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

To check the accuracy of the rotational balance, turn the stainless steel 12-72 balance weights out one quarter turn. The float must be sensitive to this unbalance. This is done on both axes.

NOTE: Plummets may be used to check fluid density while performing flotation.

D. Remove from the tank and fixture and clean the float thoroughly in varsol which has been heated to 100°F. Allow the float to cool and immerse in freon.

E. Place in a vacuum oven for a minimum of 16 hours at 180°F max.

F. Leak check and record ____________ atm-cc/sec.
Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

PREPARED BY: James Psyhogeos
DATE: January 5, 1962
M. C. #25-803
SHEET 1 OF 19

Rev. F 5/17/63
Rev. E 4/25/63
H Rev. D 11/30/62
Rev. C 8/24/62
Rev. B 2/20/62
Rev. A 1/5/62
Rev. H 9/2/64
Rev. G 12/2/63

MOD 2 WHEEL ASSEMBLY PROCEDURE

1. Bearing Measurement

a) Bearings are to be received in the disassembled state with a set of components, outer race with matching balls, sealed in its individual package, and oiled with Teresso V-78 (SCD 2021550) oil to prevent rust. The geometry and material of the supplied retainers are specified by print B-87362, or 2021569 packaged separately and shipped dry.

b) Clean the outer races and shaft in the ultrasonic cleaner, using varsol as the cleaning agent, then rinsing the parts in trichloroethylene and freon. The bearing races and shaft should then be examined under a microscope for surface defects and embedded particles.

c) Set up the precisionaire column and air rings, check the sensitivity and then make at least 4 measurements of the O. D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurement. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O. D. measurements are made and record this information together with the O. D. measurements. Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Average the values of the O. D. Set up the precisionaire column and air ring to measure the shaft .180000 diameter following the procedure outlined above.

d) Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O. D. or the shaft .180000 diameter.

e) Oil the outer races and shaft and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adaptor. The oil should be Teresso V-78 which has been taken from a bottle filled after oil filtration. It is suggested that the oil be discarded after a two month use period.

f) Seal the bearings in clean plastic bags, replace in original outer package and store until ready to use.

g) Identify the outer package with a number and record the diameters of the bearing races and shaft, together with the temperature at which they were measured, on the outside of the bearing package.

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PREPARED BY: James Psyhogeos
DATE: January 4, 1962
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E

E

Equipment

Ultrasonic Cleaner
Plastic Bags
AMSCO Bag Sealer
Master Gage Plugs, Class XXX (.180000, .180020)
Sheffield Air Ring with two small jets for measuring the .180000-.180030 diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring .3748-.3749 diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
Master Gage Plugs, Class XXX (.3748, .3749)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2. Inertia Element Assembly

a) Check inspection report on wheel hub, hysteresis ring and inertia rims.

b) Clean parts in ultrasonic cleaner.

c) Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (M. C. #25-603).

d) Place one inertia rim (O. D. chamfered end down) and the hysteresis ring in fixture B-87392.

e) Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F immerse wheel hub into liquid nitrogen, until temperature stabilization takes place.

f) With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

g) Let wheel hub slide over this post by its own weight.

h) Remove this assembly from fixture, and insert the second inertia rim (O. D. chamfered end down) into fixture and repeat steps d through g.

i) Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve A-87392.5 and an arbor press by pressing against the sleeve while rotating fixture.

PREPARED BY: James Psyhogeos
DATE: January 4, 1962
M. C. #25-803
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Rev. B 2/20/62
Rev. A 1/5/62

NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture
Depth micrometer
Thermocouple
Hot plate
Tweezers
Drake Arbor Press

3. Temperature Cycling

a) Wrap wheel assembly in aluminum foil.

b) Place in the cycling container, #2A3-10B177, evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi; seal off container and put in temperature cycling chamber.

c) Cycle the wheel assembly four times between -60°F and +200°F.

Equipment:

Cycling container
Tenney Test Chamber
Reynolds Aluminum Foil

4. Lapping Bearing Bores

a) Measure the lapping room temperature and, using the wheel assembly data sheet (M. C. 25-603), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

b) Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

c) If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator should not exceed 20 microinches, and should not extend more than .040" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

PREPARED BY: James Psyhogeos
DATE: January 4, 1962
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d) Record the actual finished bore size on the wheel assembly data sheet (M. C. 25-603).

e) Place the inertia element assembly in a vacuum oven at 150°F and evacuate for one hour at full vacuum, after cleaning in ultrasonic cleaner.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
Model 153-40 used with small jet spindles and Class XXX Master Gage Rings
Hand Lap - 3/8" dia. x 3" long - American Lap Co.
Lapping Compound 38-1200 - U. S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Oil Co., Inc.
Zeiss Stereo Microscope
Vacuum Oven - Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner

H

5. Numbering Wheel (If Inertia Rim not previously numbered)

a) Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

b) Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e. g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries Inc., Sycamore, Illinois

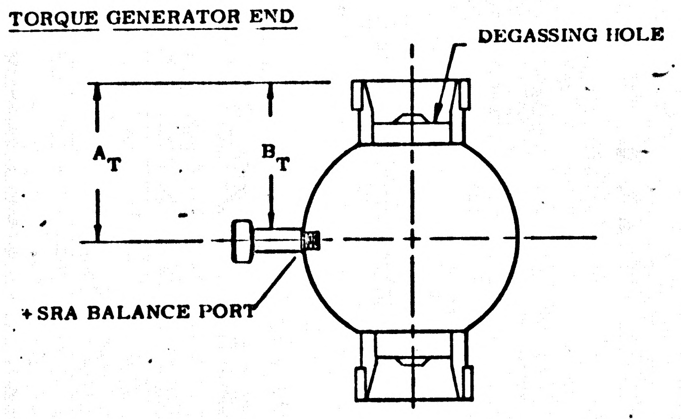
6. B Dimension Measurement (Dimension over the Hub)

Using a 0.975000 gage block and the Johansson Mikrokator S 510 E-8, measure accurately (to within 5 microinches) dimension B and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

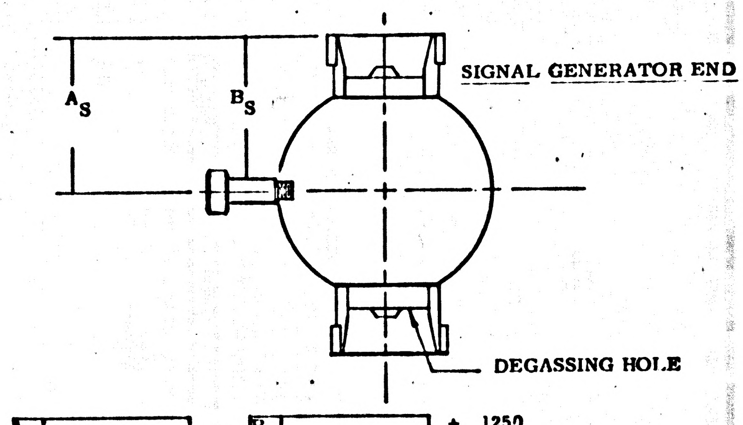
INCHES
PHOTOGRAPHIC SCALE ONLY

FLOAT MEASUREMENTS

TORQUE GENERATOR END



$A_T = B_T + .1250$



$A_S = B_S + 1250$

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5. Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.

B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter.

6. Preparation of End Housing Assembly

A. End Cap Assembly

1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.

2) Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean parts ultrasonically in trichloroethylene. Rinse in freon.

3) Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and tighten with a spline wrench. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec.

4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

B. Thermistor Installation

1) Procure thermistor per 2021518.

2) Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints. (The thermistor should be flush against the potting and between the buttons.)

3) Immerse the end housing assembly in warm varsol and clean thoroughly. Follow with a freon rinse. Store in a vacuum oven for 150 hours at 150°F.

7. Damping Block Assembly Preparation

A. Clean the damping blocks ultrasonically in trichloroethylene followed by a freon rinse.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:

A. K&D #100 round nose for spreading.
B. K&D #106 flat for staking eyelet to counterbore.
C. K&D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.

F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.

E. Repeat A through D for the second damping block.

10. Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

11. Assembly of the Float into the Main Housing

A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_T) as indicated on sheet #8 and 9. Place the spacer Z_s in the support block A-118445.

Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

B. Carefully lower the float into the main housing, with the torque generator up, the B-facing the assembler and + SRA to the left.

C. Insert the dummy stop pin A-92284 into the +SRA balance port, and secure it with a locking screw.

D. Insert the + IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer. Tooling simulating the balance adjuster may be used instead of the actual hardware for purpose of assembly until dry centering has been accomplished.

12. Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.

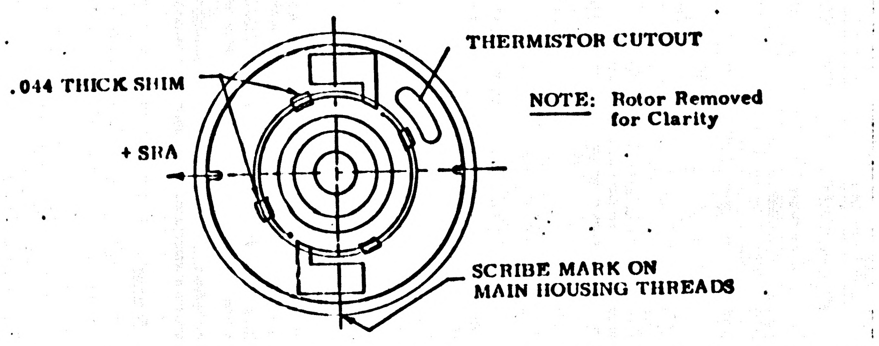
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.



NOTE: Rotor Removed for Clarity

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Equipment

C. E. Johansson Mikrokator S510E-8
Gage blocks

7. Contact Angle Measurement by Inner Race Rotation

a) Clean bearing assemblies as in paragraph 12 M. C. 25-803, steps a and b.

b) Assemble outer races as in paragraph 13 M. C. 25-803. For this measurement tapered or stepped pocket retainers can be used for assembly convenience. Important: If tapered or stepped pocket retainers are used, insure that interference is reduced to a minimum by predenting the ball pockets, eliminating possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this measurement, these retainers must not be used in the final bearing assembly.

c) Install the shaft and the mating outer race in fixture D-95850 and rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

d) Determine the contact angle using the following formula:

$$\text{Cos B} = \frac{E}{d}\left[1 - \frac{2NE}{No}\right]$$

Where E = pitch diameter 0. 24945 (print nominal value)
d = ball diameter
No = number of inner race revolutions
NE = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

Equipment

Contact Angle Gage

8. Preload Spacer Thickness Selection

With dimension A as recorded on bearing package by manufacturer, and dimension B as measured here in section 6, determine spacer thickness by using the following simple formula:

A = B + t-65 microinches
or t = A - B + 65 microinches

where t is the spacer thickness and the 65 microinches shaft deformation is explained in section 14.

9. Retainer Impregnation

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and 30 inches vacuum for five hours, minimum, to completely remove all traces of water and solvent contents.

b) Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and 27 ± 1/2 inches vacuum, outgas the retainers and oil for approximately one hour.

d) Immerse retainers in oil and hold for an additional two hours, or until all bubbling ceases.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0. 8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for two hours.

9A. Retainer Impregnation (Alternate)

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and a minimum of 29 inches vacuum for 18 hours, minimum.

b) Remove the retainers from the oven and weigh each one within 10 to 30 minutes after exposure to the atmosphere. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and evacuate to 29. 0 to 29. 8 inches vacuum for a minimum of 1 hour.

d) Immerse retainers in oil and hold for an additional 2 to 3 hours.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0. 8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for 2 to 3 hours.

10. Retainer Centrifuge - (see Appendix A)

Equipment

International Centrifuge, Model MB, Inter. Equip. Co.,
Boston, Massachusetts.

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in container assemblies #2A3-10A187-1 always keeping track of the assigned numbers, and place these assemblies in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

b) Remove from oven and install assemblies into centrifuge plate #2A3-10C187-1, and spin for 10 minutes at 6140 rpm (4000 g's).

c) Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps a and b.

d) Place retainers between two pieces of lens tissue and store in oven at 150°F for five hours.

e) Remove retainers one at a time from oven, reweigh, and compute absorption of individual retainer as follows:

$$\%\ \text{absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking.

W_2 = weight of retainer after centrifuging.

Acceptable oil absorption values are in the range of 2 to 5%.

f) Retainers shall be vacuum baked for five hours at 150°F immediately prior to bearing assembly.

10A Retainer Centrifuge (Alternate)

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in centrifuge cups, always keeping track of the assigned numbers, and place these in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

b) Remove from oven and install assemblies into centrifuge plate, and spin for 10 minutes at 4000 g's.

c) Remove retainers from centrifuge cups and clean cup assemblies ultrasonically. Replace retainers in centrifuge cups, this time with opposite faces out, and repeat steps a and b.

d) Remove retainers from centrifuge cups and wrap each one securely in lens tissue. Place in the vacuum oven for 30 minutes maximum at 150°F and 29-29. 8 inches of vacuum. Change lens tissue and repeat evacuation for 30 minutes maximum.

e) Reweigh each retainer between 10 and 30 minutes and compute the absorption of individual retainers as follows:

$$\%\ \text{absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = original weight of the retainer after baking.

W_2 = weight of retainer after vacuum blotting.

f) If the % absorption is too high or the retainer visually appears to be excessively oily, proceed to step g.

g) Wrap the retainer securely in lens tissue and place in an oven at 150 F for 6 hours. Reweigh and compute % absorption as in step e.

h) Acceptable oil absorption values are in the range of 1. 5% to 5. 0%.

11. Final Cleaning

a) Examine bearing retainers very carefully under a microscope to insure that no foreign material is present on the retainer surfaces and ball pockets; a needle and magnet can be used to remove foreign particles.

b) Clean all bearing assembly parts, except retainers, with the ultrasonic cleaner using trichlorethylene. Rinse in freon until all parts are thoroughly clean, and examine under a microscope.

c) Clean wheel inertia element, spacer caps and screws using ultrasonic cleaner and examine under a microscope.

12. Outer Race Assembly

Assemble retainers, balls and outer races as follows:

a) Install retainer over the guide post of fixture #1A3-10B150.

b) Place plug #A-92243 inside the retainer and insert balls in the retainer ball pockets.

c) Drop outer race over this assembly and press the outer race over the balls with a pair of bone tweezers.

NOTE: During this operation be careful to insure that balls are assembled with the corresponding outer races to prevent improper contact angles, resulting when outer races are mated with unmatched shaft ends.

d) Assemble the second bearing by repeating steps a, b, and c.

INCHES
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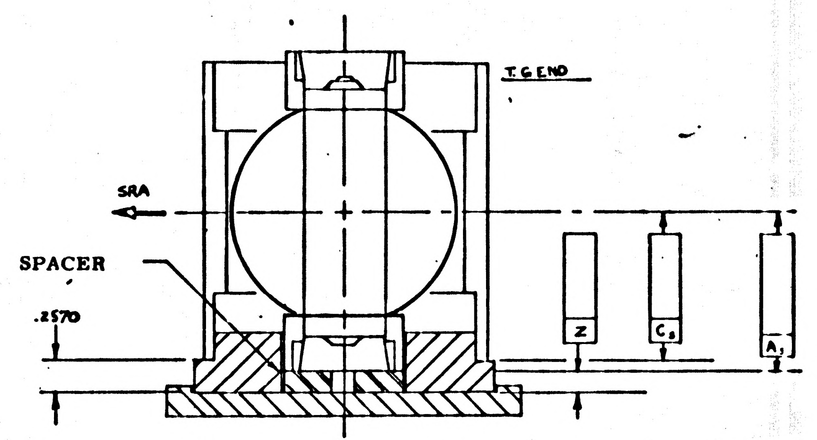
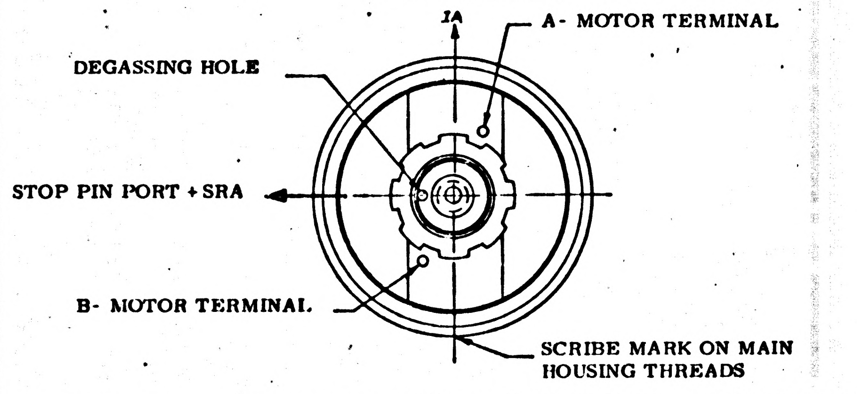


Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from page 4.

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

$$Z_s = 0.2570 + \boxed{C_3 \qquad} - \boxed{A_s \qquad}$$

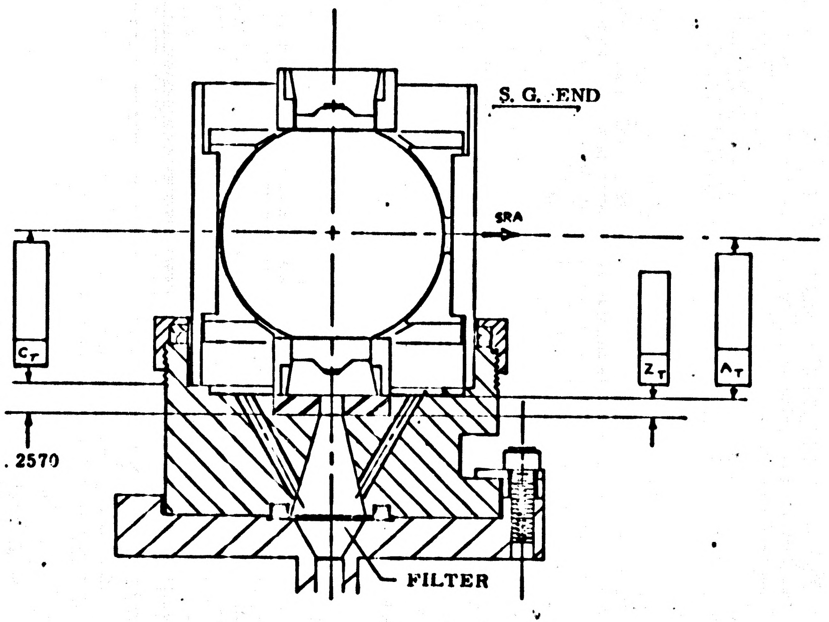


C 13. Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from page 4.



$$Z_T = 0.2570 + \boxed{C_T \qquad} - \boxed{A_T \qquad}$$

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O.D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O.D.

E. Assemble the drain block B-94086.3 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

E B H. Solder the flex leads to the float terminals as before.

C 14. Flushing the Instrument

A. Place the filter plate #2A3-10A202-1 on a 250 ml. beaker.

B. Place a #914-6 (PRP) "O" ring on the bottom of the drain block.

C. Carefully mount the instrument on the filter plate and fasten the assembly with the clamps 2A3-10A122.7 and the 10-32 NF-2 x 3/4 long socket head screws.

D. Fill a thoroughly cleaned 250 ml. beaker (3/4 full) with filtered and distilled freon. Carefully pour the freon into the open end of the instrument. Repeat the above operation until a half gallon of freon has been flushed through the unit. Allow to drain.

E. Place spacer Z_s on SG rotor face, assemble drain block B-94086.3, invert the instrument and reflush 1/2 gallon and drain.

F. Carefully remove the unit from the filter plate and insert a clean millipore filter 2A3-10X202-8 on the filter plate. Assemble unit to plate as before. Repeat flushing operation.

G. Remove the filter and examine under a 30X or 40X microscope. If filter shows a high dirt count, insert new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under microscope.

C 15. Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 70 microinches.

E. Care should be taken to insure that the pivot ball is not touched. Very carefully insert the pivot into bore (no pivot rotation) until it bottoms on the jewel end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

C 16. Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet #13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut. Omit this step if simulated + IA Balance Adjuster is used.

C 17. Dry Centering

A. Dry center the instrument as per MC 25-854.

C 18. Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 50 in-lbs. Invert unit and repeat above procedures. D

C 19. Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate:
Maximum Allowable Leak = 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page #13.

Equipment

1) Fixture #1A3-10B150
2) Plug #A-92243
3) Bone Tweezers

13. Bearing Installation

E a) Place the wheel assembly on the holding fixture #A-88948.3 with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

b) Lay the bearing marked II on the bore and with bone tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

H c) Place a spacer B-97652 or 2021667 over the bearing and use fixtures A-88948.1 and A-88948.2 to press the bearing into the bore. The force necessary to push the bearing into the bore will be in the range of 3-8 pounds (reference).

d) Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step c above, press bearing into its final position.

e) Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight.

f) Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

E g) Screw adaptor A-92246.2 into end I of the bearing shaft and holding only the adaptor, guide the shaft through the wheel bore until the shaft end marked II replaces the plug inside bearing II. The wheel now is supported by the shaft. Reverse the position of the wheel and place this assembly on the fixture.

h) Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

i) Repeat step b above for bearing number 1.

j) Select a spacer 0.0005" thicker than the calculated size and use fixture A-88948.1 and A-88948.2 to press the bearing into the bore (the use of a thicker spacer is suggested to prevent brinelling of the bearings in case of error in measurements).

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k) Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

H l) Install beryllium cap and insert four 0-80 Allen Head screws .187 long. Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum, without, however, placing any preload on the bearings.

m) Remove screws, beryllium cap, and spacer.

14. Shaft strain

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary.

The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

H a) Insert a 416 stainless steel rod (.093 diameter x 1.270 ± 0.001 long) into the .101 shaft I.D. Optional MTL: 52100 steel.

b) Assemble top adaptor #A-92246.1 to the II shaft end with the flat end inward and tighten to a torque of 0.75 in. lb (strain gage measurements at M.I.T. indicate that 0.75 in.lb or torque produce 76 microinches/inch shaft strain and correspondingly approximate 65 microinches shaft deformation).

The 65 microinches shaft strain will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adaptors and shaft will not be removed until that time.

15. Final spacer selection (Preload Fixture D-92272)

a) Assemble shaft adaptor #A-92278, to the #2 end of wheel.

b) Assemble shaft cap #A-92277 to the #1 end of wheel. In assembly of these adaptors insure that the applied torque does not exceed 0.75 in. lb.

c) Position wheel on top plate #C-94190, the chain that is attached to shaft adaptor #A-92278, should protrude through the bottom of the plate #C-94190.

d) Place clamping ring #B-94185, on top of wheel insuring that the teflon washer #A-94186 contacts the wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

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e) Attach weight pan #A-92281 to chain hanging from shaft adaptor #A-92278.

f) Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying six pounds load. Lift weight and zero meter and then gently apply the six pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

NOTE: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of thewheel. Loosen clamping screw and reposition wheel.

g) Remove Mikrokator tip from wheel hub and insert spacer of thickness t (see 8) and beryllium cap on wheel hub. Position the beryllium cap by inserting the #0-80 Allen head screws. At this time do not tighten the screws against the cap.

h) Place Mikrokator tip on the high point of shaft cap #A-92277.

i) Apply three pounds axial load and record the Mikrokator meter reading. This is the reference point to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point. Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

j) Using an Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation extreme care should be taken to insure that no part of the apparatus is disturbed.

k) Rotate the bearing shaft approximately 10 revolutions before recording the mikrokator deflection. If the difference between this measurement and the reference established in step (i) is within ±10 microinches, the proper preload has been achieved. If not, change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference. Repeat the measurement.

H l) Measure axial compliance by hanging one, three, and four pound weights on the shaft end and recording the displacement of the indicator from zero for each weight. These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on MC-811.

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16. Dynamic Balancing (Preliminary)

NOTE: Balancing may be performed after temperature cycle (17).

a) Remove the wheel from the compliance fixture and mount in Dynamic Balancing Machine. Adjust excitation gain to turn wheel over slowly (60 rpm) approximately for one minute to lubricate the dry metal parts.

b) Dynamically balance the wheel until the residual unbalance is no greater than 0.25 dyne-cm. The corrections should be made by filing the O.D. of the inertia rms with the correction planes as far apart as possible. Prior to making balance corrections both ends of the wheel must be carefully sealed off with rubber cups to protect the bearings.

c) Examine the areas of the wheel and bearing shaft under a microscope and remove any trace of contamination. Before removing cups, clean the wheel thoroughly with suction hose.

d) Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)

H Alt: Schenk Balancer Model #R-06

17. Temperature Cycling (Bearings Installed)

a) Wrap wheel in aluminum foil, and place in the cycling container, 2A3-10B177.

b) Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.

H Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere

H c) Cycle the wheel assembly four times between +40°F and 180°F.

Alt Cycle: 32°F to 180°F

d) Refer to MC 25-838 for dynamometer testing.

H Equipment

Cycling Container   Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: February 26, 1964

MC 25-853

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OF 13

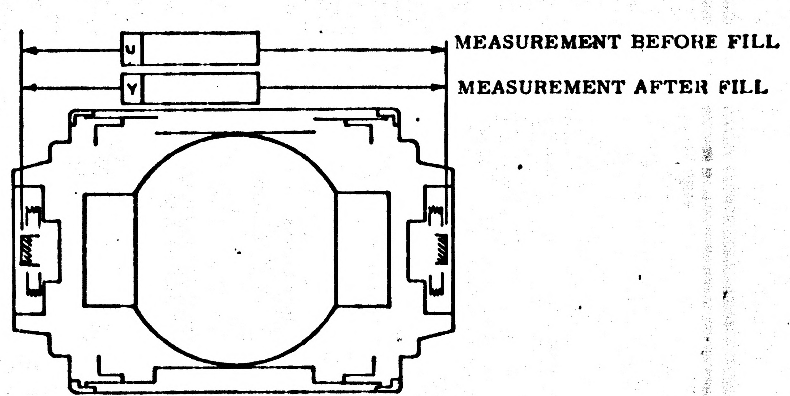
CB 20. Bellows Measurement .

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)-- ☐ Grams

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CAMBRIDGE, MASS.

PREPARED BY: A. Arns
DATE: 2/7/64

MC# 25-853

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OF 13

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_y					
S_H TO S_L						T- TO T_y					
S_L TO SSQ1 SEC						T_y TO T_c					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT

A- TO A+						
B- TO B+						
A- TO B-						
A+ TO B+						

18. Sealing Cap Screws

Remove wheel from the dynamometer and place it in stand #A-88948. 3. Remove Allen head screws on number one end of wheel, and insert cap centering ring #A-92244, around cap and wheel hub neck to eliminate cap run-out. With the cap now well centered, insert final 0-80 screws and tighten firmly. Remove cap holding screws one at a time, and with a very small drop of Loctite, tough the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace screw and fasten firmly.

a) With a microscope examine the area around the screw head and wipe off any excess Loctite. (Loctite will not cure if exposed to air). Repeat this procedure to all 8 screws.

Alt: LCA-4 (2021552) may be used as a substitute for Loctite.

b) To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures #A-88948. 3, A-92244.
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant
   American Sealants Co., Hartford 11, Connecticut
5) LCA-4 per SCD 2021552

19. Dynamic Balancing (Final)

a) Check the final balance of the wheel as in paragraph 17 and make necessary corrections to achieve a maximum residual unbalance of 0. 10 dyne-cm. Also measure and record the bearing noise level.

NOTE: This check should be made with the wheel at operating temperature as follows:

To bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O. D. of stator housing.
2) Cover the stator housing and entire rotor platform with a foil lined beaker.
3) Run the wheel at synchronous speed until the Alnor meter indicates 155° - 160°F. Wheel temperature will now be within the operating limits.

Rev. G 12/2/63

Equipment

Micro Dynamic Balancer, Model K-1
   Micro Balancing, Inc.
   Garden City Park, Long Island, New York
   (includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
   Alt: Schenk Balancer Model #R-06

20. Final Inspection

a) Place wheel under microscope and inspect for lint and dust particles.

b) Clean off with vacuum hose and repeat (a).

c) Place the wheel in a plastic bag and hermetically seal in a vacuum.

Equipment

Zeiss Stereo Microscope
Vacuum hose
Plastic bag
AMSCO Bag Seal
} or Equivalent

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Rev. B 2/20/62
Rev. A 1/5/62

21. Installation in Float

Install the wheel into the float according to the Float Assembly Procedure MC #25-810 or MC #25-855.

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

a) Assemble adapter #A-95721, firmly to the VS-10.

b) Thread lock-nut #A-92357, to the 12-72 stud until it bottoms.

c) Assemble the (-) SRA end of the float to adapter #A-95721 very carefully until it bottoms, then back the float off one full turn.

d) Fasten the float by bottoming lock-out #A-92357 firmly against the bushing, using spanner wrench #A-92359.

e) Set variable frequency oscillator at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 470-580 mv.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

---

f) Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V. T. V. M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat step f three times and take the average of the resonant frequencies.

g) Using this resonant frequency and curve (sheet 22), determine the axial compliance of the wheel.

h) This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on M. C. #811 within ± 0. 25 microinch/lb.

i) If the axial compliance as determined in step (g) above is higher than the compliance recorded on M. C. #811, insert wrench #A-92262 in the +SRA bushing and lock wrench firmly by turning locking screw.

j) Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel installed in the float). Remove wrench #A-92262, and steps f and g. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step (g) is lower than that recorded on M. C. #811, insert wrench #A-92262, and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps f and g. It is suggested that the torque values are increased in increments of one inch-lb at a time until the required compliance is achieved.

k) With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as is steps c and d.

l) Determine the radial compliance repeating steps f and g.

m) Record both axial and radial compliances in M. C. #25-605.

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, Δ C, is equal to or less than 0. 75 microinches/lb. If the term Δ C is greater than 0. 75 microinches/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4°/min max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0. 5 microinches/lb. of the value recorded in M. C. #811. If the compliance is outside the imposed limits, the float should be re-torqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

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n) Using a spade oiler, or other suitable tool, apply LCA 9, (SCD 2021529) MC 25-302, to the -SRA bushing and torque to 5 inch pounds.

o) Remove the +SRA bushing and repeat the cementing operation per step n, replace the +SRA bushing and torque to 3 inch pounds.

p) Repeat steps a through m as necessary to reset compliance. (Note: the torque required at this time will be higher than the initial torque).

q) Cure assembly for 2 hours at 180°F maximum.

r) Recheck compliance after cure and record on MC 25-605.

22. Final Run-In

a) Insert the thermistor holder #2A3-10A180-1. 2 with the Fenwal Thermistor probe, into one of the IA balance ports.

b) Install the float into fixture #C-87364 and attach power and thermistor leads onto provided terminal strip.

c) Install top plate #A-87364. 1 on top of the float.

d) Turn the power supply and heater on and set the Fenwal indicator at 137 . After one hour of wheel running, take run-down time and run-up time measurements per MC 25-834. Record these measurements and all other parameters called out on MC 25-605.

The speed and inertia of the Mod 2 wheel affect greatly the spread of the run-down measurements if taken from 24000-0 rpm. For this reason the run-down time measurements will be taken from 24000-6000 rpm and 6000-0 rpm. To do this, follow the following procedure:

1) Insure that the oscillator of the wheel power supply is 800±3 cps, and take a run-down time measurement as per MC 25-834.

Run-down time measurements should be taken twice in every 24 hour period with a minimum of 4 hours between measurements and recorded on MC 25-605. The total wheel run-in time, including dynamometer should be 200 hours. This should include 120 hours minimum of dynamometer time and a minimum of 80 hours of float time since the last torquing or cycling.

When the wheel has completed its run-in period the average wheel run-down time (A_F) and the rms of the deviations from average can be computed. The only imposed run-down time limit is $6_F \leqq 4.0$

PREPARED BY: James Psyhogeos
DATE: January 5, 1962
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where $\sigma_F = \sqrt{\dfrac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots\ (T_n - A_F)^2}{n}}$

A_F = average run-down time to 6000 rpm.

n = number of run-down time checks (no less than 7)

T_n = RDT to 6000 rpm

NOTE: During the 80 hour minimum run-in period observe carefully the values of --a) power input, b) run-up time and c) run-down time. The run-up time should be taken with the voltage fixed at 28 volts, and it should repeat within one to ten seconds.

Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection, etc.); then, if the condition continues, reject the float assembly.

23. Delivery

Continue float assembly per MC 25-810 or MC 25-855.

PREPARED BY: James Psyhogeos
DATE: January 5, 1962
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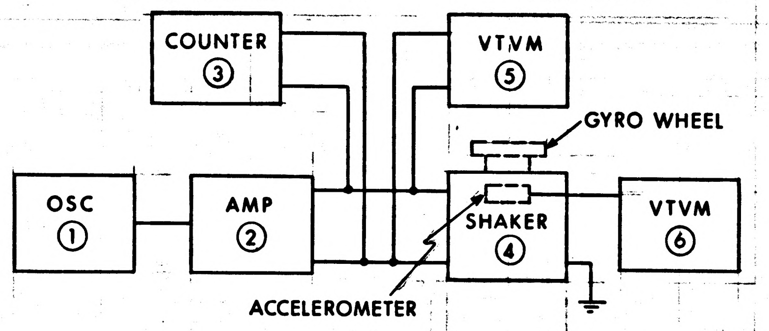
Compliance Checking Equipment

Mod 2 Gyro



1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. V. T. V. M. - Ballentine Model 300E

PREPARED BY: James Psyhogeos
DATE: January 5, 1962
M. C. #25-803
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APPENDIX "A"

CENTRIFUGE

$$\text{"G" level} = \frac{w^2 r}{g}$$

w = rad/sec
r = inches
g = 386 in/sec^2

$$w = N\,\frac{\text{Rev}}{\text{Min}} \times \frac{1\ \text{min}}{60\ \text{sec}} \times 2\pi\,\frac{\text{rad}}{\text{rev}}$$

$$w = N\,\frac{\pi}{30}$$

$$\text{"G" level} = \frac{\left(\frac{N\pi}{30}\right)^2 r}{g}$$

N = rpm
r = inches
g = 386 in/sec^2

APOLLO II IRIG Specification
MC 25-855
Release Date 25 Nov. 1964
Release Revision A
Class A **Release**
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
4-30-65	B	18829	1, 4, 5	WK	WJR
3/21/68	C	35603	4, 5	DRK	
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8	DRK	
1/31/69	E	37288	1-3	MGM EA	WLS
4/21/69	F	37524	3, 6	MGM EA	WLS
6/17/69	G	37671	All	MGM EA	MH
7/8/69	H	37702	6, 7	RM, EA	MDH

TP#11938

This MC specification consists of page i ~~15~~____and 1 to 9 inclusive.

FLOAT ASSEMBLY PROCEDURE

Examine the inspection report accompanying the float, and bring to the supervisor's attention any deviation from the print.

The wheel shaft, and float hemispheres must be matched for a .000025" ± .000015" interference fit.

1.0 Record the O. D. of the wheel shaft. This information will be found in MC 25-605.

+SRA______________ -SRA______________

Record the I. D. of the float hemisphere bores.

+SRA______________ -SRA______________

Average Interference

+SRA______________ -SRA______________

2.0 Lap the #12-72 and #5-40 balance weights, also the #2-56 sealing screw to insure a smooth fit. Extreme care should be taken with # 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305 A lapping compound. With a dummy shaft #A-92245 lap the #5-40 threads of the bushings. Refer to MC-400 for handling beryllium.

3.0 Carefully examine the jewel and end stone area under a microscope for any residual adhesive. This area can be cleaned using a .040" drill blank charged with #305 A lapping compound.

4.0 Clean all the float parts ultrasonically in clean trichloroethylene for a minimum of three (3) minutes, followed by an ultrasonic rinse in

---

clean freon for the same time period.

5.0 Weigh all the float parts and record this information on the float weight sheet.

6.0 Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in acetone, followed by cleaning as in step #4.0.

7.0 Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8.0 Measure and record the following:

A) O. D. of stator ________________

B) I. D. of gimbal ________________

Subtract the gimbal I. D. from the stator O. D. and enter in "C".

C) Average interference ________________ (.0001"-.0003")

9.0 Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ± 10° for about fives minutes.

B. Place the bushing A-92287 into the pressure plate.

C. Assemble the motor stator to the pressure plate A-87423.

D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O. D.

F. Remove the gimbal and fixture base from the hot plate.

G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the the stator bottoms on the base.

H. Remove fixture and check centering of the stator in the gimbal. Check continuity. (Stator should be centered to within .005")

I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F ±5° oven and cure for 1 1/2 hours minimum.

10.0 Weigh gimbal and record________________gms.

11.0 Grind I. D. of motor stator as per drawing 2021625.

12.0 After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol(room temperature or warm 90°F ± 5°) followed a thorough rinsing in clean freon.

13.0 Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.

14.0 Weigh gimbal and record________________gms.

Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet.

15.0 Power Lead Installation

A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ±5° oven for 1/2 hour minimum.

B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O. D. of two power leads and to the gimbal counter bores and insert the the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal.

Cure for one hour at 180°F ± 5°.

C. Repeat step "B" on opposite end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063" diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F±5° minimum.

E. Remove from oven and fill the back side of the two remaining .063" diameter holes and cure for two hours at 180°F±5° minimum.

16.0 Install .062" diameter ball and #2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10×10^{-8} ATM cc/sec. Leak rate_______________

17.0 Cycle the gimbal from 40°F to 180°F four (4) times, with a dwell time of one (1) hour at the extremes. Alternate cycle +32°F to +200°F four (4) times. Releak check the gimbal. Maximum allowable leak rate= 0.10×10^{-8} ATM cc/sec. Leak rate=_______________ATM cc/sec.

18.0 Remove the sealing screw and .062" diameter ball, Re-assemble the #2-56 sealing screw to the gimbal. Do not tighten.

19.0 Assembly of the Wheel to the Float

A. Thoroughly clean all the float parts, and fixtures to be used, in clean filtered freon. Follow by a thorough vacuuming.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on a thermostatically controlled hot plate set to 350°F +15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms. (Balancing numbers + SRA)

NOTE: Nylon gloves or clean finger cots to be worn when handling wheel.

D. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

E. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

F. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F±5° for approximately 15 minutes.

G. Heat the -SRA hemisphere as in "B" of step #19.

H. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

I. Carefully assemble the wheel and +SRA hemisphere down over the guide post until the wheel is bottomed into the -SRA bore, aligning the scribe marks as closely as possible. Allow to cool as in "D".

20.0 Balancing the float in air

A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the balancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

Change in shim thickness = $\frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg. of tape to achieve balance along SRA.

21.0 The float at this time is complete except for the rotors and balance weights. Weigh the float and record_______________gms.

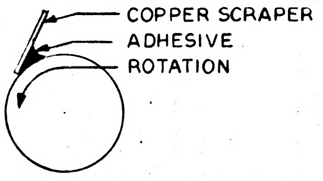
22.0 Mount the float on centers-fixture 2A3-10B186-2 and measure the runout of the stub shafts. T.I.R. should be no greater than .0002". Measure the runout of the sphere and record. Figure 3.

23.0 Refer to MC 25-803, MC 25-869, MC 25-880 or MC 25-897 for setting compliance.

24.0 Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ±5° oven for 45 minutes minimum.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure 1.



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure and leak check.

C. Cure for one hour at 175°F ±5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ±5°.

25.0 Filling the Float with Helium

A. Weigh the float, the #2-56 sealing screw and ball and record.

_______________gms.

B. Place a #2-56 x 3/32 long S.S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062" diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to O" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive The ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw, using 25 to 30 in. oz of torque.

The following alternate procedure may be used:

Install float in fixture as described in "B". Draw a vacuum of 15" Hg and then admit helium to O" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as before.

C. Weigh the float and record _______________

D. Compare the weight of the float before and after filling and record the decrease in wieght which should be approximately 18 mg. _______________ gms.

26.0 Leak check and record _______________ atm-cc/sec.

Acceptable leak rate = 5×10^{-8} atm-cc/sec.

27.0 Cycle the float four (4) times from +40°F to +180°F at an approximate rate of 3°/minute, with a dwell time of one (1) hour at the extremes. Alternate cycle at +32°F to +180°F at a rate of 4°/minute.

28.0 Leak check and record _________ ATM-cc/sec.

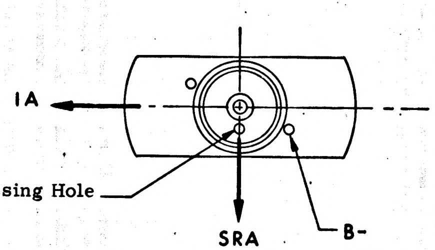
Maximum allowable leak rate = 5×10^{-8} ATM-cc/sec.

29.0 Refer to MC 25-803, MC 25-869, MC 25-880 or MC 25-897 for float run-in procedure.

FLOAT WEIGHT RECORD
Apollo II IRIG
(FOR REFERENCE ONLY)

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
2021513	4	Power Lead-in		.092	
2021634	8	Balance Weight (Final Rot. Adj.)		.740	
2021635	4	Balance Weight Spring		.018	
2021636	2	Centering Shim		.013	
2021631	2	Bushing		1.676	
2021528	1	#2-56 Sealing Screw		.037	
2021532	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
2021627	2	Hemisphere		14.701	
2021628	1	Gimbal		26.051	
2021632	1	Motor Stator (Finish Ground)		18.800	
2021637	2	Rotor Assy. *		32.968	
2021701	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
2021633	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.



(View from T. G. End)

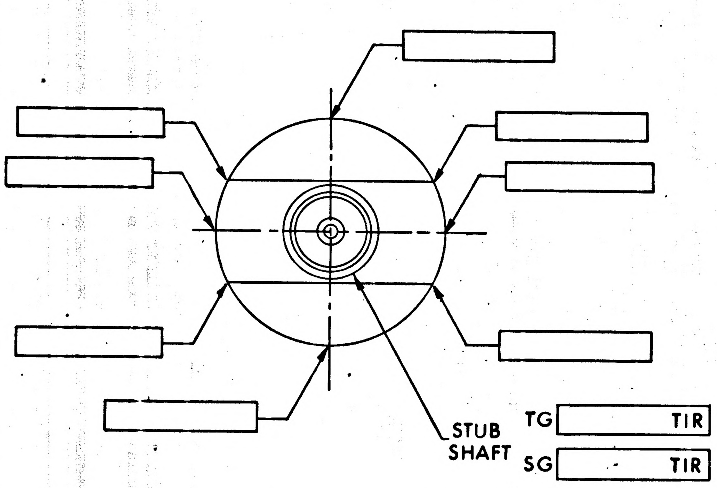


Fig. 2 Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC -25-808 REV H
Release Date Nov 1 1964
Release Revision Rev E
Class ______ Release
TDRR 14016

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
6-24-68	F	36405	1, 4	PRK 73	
1/21/69	G	37218	3	MGM EA	WLS
1/22/69	H	37219	3	MGM EA	RJJ

TP#11938

This MC specification consists of page 1 to ___ and 1 to 4 inclusive.

TDRR 14046 NOV 4 1964

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808
SHEET 1 OF 4

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

1. Stator Core

E B E Heat treat laminations B-62045 (2021674) per MC #105. Remove all burrs and throughly clean laminations according to MC 25-900. Bond laminations using fixture #2B3-10B12 per MC 25-300. There are approximately 33 laminations to a stator core. Coat all surfaces except O.D. with Hi-Dielectric Enamel by American Durafilm Co. (2021539) (2 coats 0.005 max. thick.).

2. Winding

Lap wind core as follows:

56 turns per coil of #35 A.W.G. aluminum wire, heavy silicone coated (2021540) 4 pole, 2 phase, 3 coils per pole per phase, 1-5 throw 2/3 pitch. Lap wind starting with phase B in slots 1-5 2-6 3-7; then phase A in slots 4-8, 5-9, 6-10. The slots are numbered C.C.W. as viewed from the side the leads come out.

3. Inserting Slot Cell Paper

D After the second coil of A phase has been wound (5-9), there will be two coil sides in slot #5. Insert slot cell paper dwg. A-107247 (20221583) in slot #5 between winding and core. This is done by compressing the winding with a wedge-shaped wooden peg away from the slot opening on both sides of the core. Compress winding under slot opening by carefully pushing through a long pointed wooden peg between the winding and core. Insert the small end of slot cell paper in this space. Pull paper through from the opposite side until it fits snug. Cut paper on both sides as close to the core as possible. Paper should lie flat and extend equally on both sides of the slot opening.

Insert slot cell papers after each successive coil has been wound.

4. Location of Winding Leads

Looking at the finished-wound stator from the winding lead side (top side) and calling the slot having the first half turn of the first coil as slot #1, number the slots C.C.W. from 1 to 24. The four winding leads are identified

Rev. D 1/17/63
Rev. E 9/10/64

Rev. B 8/31/62
Rev. A 11/1/61
Rev. C 12/20/62

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as follows: B+ Slot #1 B- Slot #21
A+ Slot #4 A- Slot #24

Check for continuity of each phase, for grounds in each phase, and for shorts between phases.

Position the winding leads as follows:
A+ to Slot #12 (bottom) A- to Slot #24 (bottom)
B+ to Slot #16 (top) B- to Slot #4 (top)

To bring B+ and B- to their respective slot positions, weave the leads through the winding so as to follow the winding pitch. Bring A+ to Slot #12 in the same manner and insert lead under slot cell paper. Position A- by removing one half turn and looping under coil. All winding leads should come out from the inside of the stator winding at the appropriate slot position.

Cut leads to 2" lengths and strip insulation with X-Var stripper down to about 1/4" from the top of the winding end turns. Clean stripped leads with Kimwipe (soft tissue) saturated with Denatured Ethyl Alcohol. Check for continuity, grounds, and shorts between phases.

5. Tin the four winding leads per MC 25-819.

6. Soldering Winding Leads to Terminal Leads

Use four 5" lengths of #35 A.W.G. H.F. copper wire for terminal leads. Strip, clean and tin 2" of each terminal lead. Insert terminal leads under slot cell papers at the appropriate positions so that they can be soldered to the winding leads. Pigtail the tinned portion of each winding and terminal lead. Solder pigtails using the tinning procedure of MC 25-819. Cut pigtails E to 1/4" and insulate with Mylar tape or shrinkable sleeving per NASA dwg 1010490-120.

7. Forming (Forming Fixture A-87414)

Use a wedge-shaped wooden peg and carefully form the O.D. of the winding on both sides so that it will clear the I.D. of top and bottom plates of forming fixture. Assemble stator to plates. Visually check assembly for pinched wires.

Form I.D. of stator on both sides so that it will clear O.D. of upper and lower supports. Assemble supports to stator and check for pinched wires. Lay the terminal leads on the top of the stator winding. Assemble forming

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fixture. Check for continuity, grounds and shorts between phases.

8. Connecting (Terminal Pins to Terminal Leads)

Strip, clean and tin the four terminal leads down to about 1/8" from the top of the winding end turns.

Clean the tinned terminal leads and four motor terminals with denatured ethyl alcohol.

Hold terminal with a pair of tweezers and place a drop of Kester E soldering Flux #1571 on top of terminal. Melt a small bead of 96.5 SN, 3.5 AG solder on soldering tip. Sweat solder into terminal hole until it is completely filled.

E C **Hold solder filled terminal with a pair of tweezers and sweat terminal down over the terminal lead to proper height. (Do not allow terminal to drop below the tinned portion of the terminal lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.** the lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.

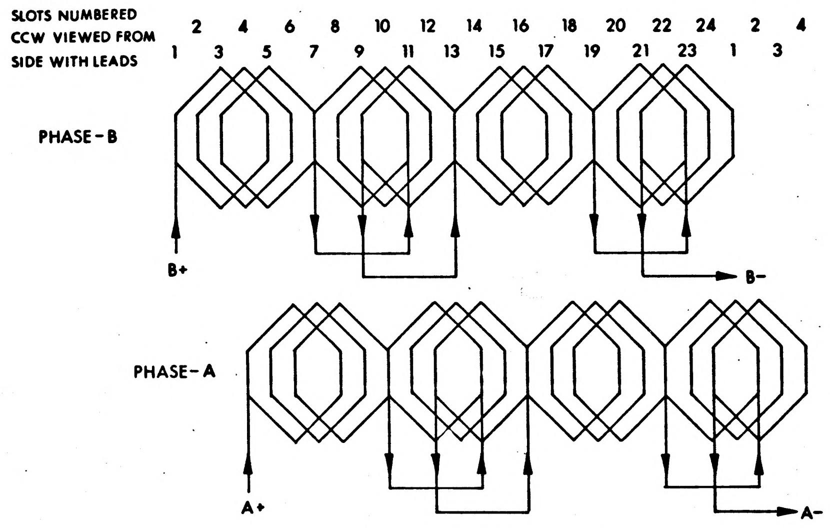
Check for continuity, grounds, and shorts between phases.

9. Potting Procedure: potting mold per MC 25-504.

9.1 For 2021632-000 and 2021632-011 assemble stator to potting mold per MC 25-504.

9.2 For 2021632-021 assemble stator to potting mold per MC 25-913.

IL 27


SLOTS NUMBERED
CCW VIEWED FROM
SIDE WITH LEADS
2 4 6 8 10 12 14 16 18 20 22 24 2 4
1 3 5 7 9 11 13 15 17 19 21 23 1 3
PHASE-B
B+
B-
PHASE-A
A+
A-

ARROWS INDICATE DIRECTION OF WINDING

WINDING PROCEDURE:

1. WIND FROM TWO SPOOLS USING ONE CONTINUOUS LENGTH OF WIRE FOR EACH PHASE.
2. LAP WIND, STARTING WITH PHASE B IN SLOTS 1-5, 2-6, 3-7, ETC. THEN PHASE A IN SLOTS 4-8, 5-9, 6-10, ETC.
3. EXCITATION PHASE ORDER A, B APPLIED TO TERMINALS A & B RESPECTIVELY WILL PRODUCE C.W. ROTATION FIELD, VIEWED FROM THE SIDE WITH LEADS
4. Nominal DC resistance per phase at room temperature= 67Ω

4 - POLES
2 - PHASE
3 - COILS/POLE/PHASE
#35 - AWG HEAVY SILICONE COATED ALUMINUM WIRE
56 - TURNS/COIL
1-5 - COIL THROW
2/3- PITCH

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APOLLO II IRIG Specification
MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG
General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
12-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13	[illegible]	[illegible]
[illegible]	C	22893	5, 6, 7, 9, 10, 11, 12	WK	[illegible]
10-8-65	D	23195	11, 12	WK	N/A
11-12-65	E	25210	10	WK	A. C. METZGER
9-27-67	F	34995	10, 11	PRK	See TDRR
2-16-68	G	35662	2, 7, 11	PRK	See TDRR
2-20-68	H	35689	1	PRK	See TDRR
6/21/68	J	36402	All	PRK	See TDRR

This specification consists of pages i to ____ and 1 to 15 inclusive.

Final Assembly Procedure for 25 Apollo II IRIG General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. Prior to the final assembly, the work area should be thoroughly cleaned, and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be clean. All turn-around subassemblies and parts previously exposed to BFC damping fluid shall be cleaned per ATP 2021500, MC 25-902. The work area, preferably a laminar flow cabinet. All parts and subassemblies brought into the area should be in clean glass covered containers. Do not use plastic boxes or bags. A vacuum line should be available and constantly used during this operation. All turn around sub-assemblies and parts previously exposed to (BFC fluid) damping fluid, shall be cleaned per ATP 2021500, MC 25-902.

1.0 Sub-Assemblies and Parts to be Demagnetized

- A. All magnetic parts prior to final assembly.
- B. Float Assembly, Dwg. 2021619.
- C. End housing assemblies, Dwg. 2021663 and 2021649.

2.0 Float Preparation

A. Cementing the rotors to the stub shaft.

1) Screw the carbide pivot 2A3-10A113. 2 into one of the 12-72 balance ports.

2) Assemble the rotors to the float to insure proper seating.

3) Remove the rotors and apply a small head of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the 5-40 tapped holes.

4) Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.

5) TG rotor should be aligned per MC 25-618 step A, 11.

6) Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.

7) Place assembly in oven and cure for 1-1/2 hours minimum at 150° ± 5°F.

H. Carefully mount the float in the adjustable centers, fixture 2A3-10B186.2 and check the rotor runouts and record on page 16.

I. Insert reference pin 2A3-10A124. 3 into the +SRA Port. With depth micrometers measure and record the required dimensions on page 4.

J. Thread one (1) of the # 12-72 balance weights into the float bushing until it bottoms.

K. Place the balance weight spring (arch side up) and thread the second weight to its maximum travel, and if necessary, back off to achieve alignment. Check the tightness of the weights with a torque watch applying 5-8 in.oz. of torque.*

L. Repeat steps "J" and "K" for the remaining weights.

M. Determine the number of turns available and set all the weights at their mid-position.

3.0 Flotation and Rotation Balance

A. Determine the neutral buoyancy, end for end, and rotational balance as follows:

- A. Place the float in a 135°F ± 5° oven for a minimum of fifteen minutes.
- B. Fill the flotation tank, 2A3-10C165.1, with flotation fluid, 2021512.
- C. Adjust the temperature of the tank to 137°F ± 2°F to achieve a density of 2.3850 ± .002 gm/cc. Depending on the density of the lot of the fluid to be used to fill the unit, select the appropriate plummet and check the density of the flotation fluid, which should be in the range as indicated above.

* Note: This value is (wet) torque, obtained by lightly lubricating weights with BFC fluid, followed by cleaning in prescribed manner.

D. Add # 5-40 balance weights to the float stub shaft to bring the float weight to 183.8 grams.

E. Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 5 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.
Remove the float and solder weights from the tank, and thoroughly clean the solder weights in warm varsol, followed by a freon rinse. Weigh the solder weights.
Weight in air of solder on holder at TG end ____________
Weight in air of solder on holder at SG end ____________
Compute the effective weight of the solder in fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.755
Mallory 1000	0.884

Weight (in air) added to TG end ____________
Material ____________
Weight (in air) added to SG end ____________
Material ____________
Total float weight in air ____________

5. Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.
Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg. it will not be necessary to make any further adjustment.

H. Place the float in the rotational balance fixture B-84056, allowing

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some end play and heat in a 137°F oven for 15 to 20 minutes. Place assembly back into the tank and degas for approx. 10 minutes.

Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.

To check the accuracy of the rotational balance, turn the stainless steel # 12-72 balance weights out one half turn. The float must be sensitive to this unbalance. This is done on both axes.

L. Remove the float from the tank and thoroughly clean by immersing in warm varsol 90°F ± 5°. Follow by rinsing in warm filtered freon. Repeat this cleaning procedure two-three times, changing the fluid, after each cleaning.

J. Place in a vacuum oven for a minimum of 16 hours at 150°F ± 5°.

F. Leak check and record ________ atm-cc/sec.

Max. Acceptable Leak Rate 5×10^{-8} atm-cc/sec.

L. Store this assembly in a clean glass container until required.

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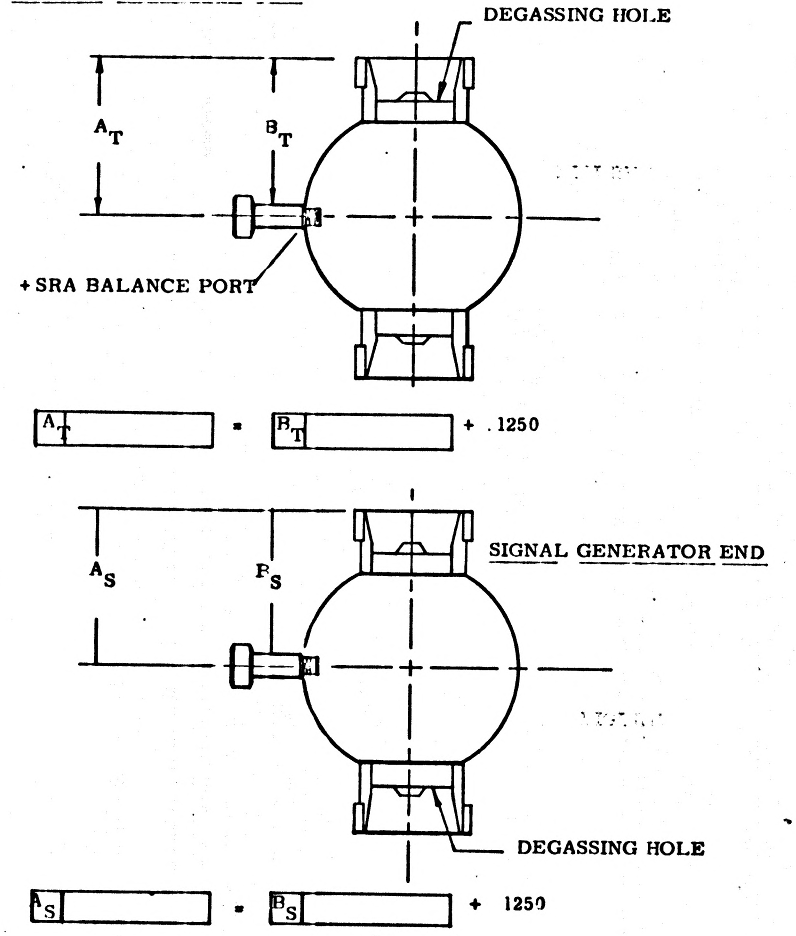
FLOAT MEASUREMENTS

TORQUE GENERATOR END



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4. Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96×5/32 long screws using 305A lapping compound.

B. Examing the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter. Refer to MC 400 for handling beryllium.

5. Preparation of End Housing Assembly

A. End Cap Assembly

1) Lap the 3-56 spline head screw to bellows, using 305-A lapping compound.

B. Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean all the parts ultrasonically in trichloroethylene for five minutes minimum. Follow with an ultrasonic rinse for the same time period in clean freon.

C. Assemble the end cap gasket, the end cap, pressure washer and locking ring to the end housing. Insert the 0.078 aluminum ball and 3-56 sealing screw and torque to 28-30 in. oz. Leak check. Maximum allowable leak rate is 1.0×10^{-8} atm-cc/sec. and torque to 50 in-lbs.

4) Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

E. Assemble the end caps to the extension fixture and repeat cleaning as in step "B".

F. Place the end caps into a clean glass covered container, and store in a 150°F ± 5° vacuum oven until required.

B. Thermistor Installation

1) Procure thermistor per 2021518.

H. Solder the thermistor lead to the buttons on the end housing using 60-40 solder and Kester 1571 flux. Clean the solder joints with an acid brush and trichloroethylene followed by a rinsing in clean freon.

I. Carefully inspect the end housings under a 30X microscope for loose or flaking compound, metal smears, flux residue, quality of the two (2) contact buttons, cracked potting and cleanliness of the two (2) fill holes.

J. Thoroughly clean the end housings by scrubbing while immersed in warm varsol 90°F ± 5°. Rinse in warm freon.

K. Store the assemblies in a 150°F ± 5° vacuum oven for a minimum of 150 hours.

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6. Damping Block Assembly Preparation

A. Clean the damping blocks ultrasonically in trichloroethylene for three (3) minutes, followed by an ultrasonic rinsing in freon for three (3) minutes.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K&D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used:

A. K&D #100 round nose for spreading.
B. K&D #106 flat for staking eyelet to counterbore.
C. K&D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flux lead tabs side and top using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by a freon rinse.

F. With an artist brush, apply a thin coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

8. Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005 wide x 0.007 thick) on fixture B-113078. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

9. Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with Trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.

E. Repeat A through D for the second damping block.

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10. Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

10. Assembly of the Float into the Main Housing

A. Insert the +IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer. Tooling simulating the balance adjuster may be used instead of the actual hardware for purpose of assembly until dry centering has been accomplished.

B. Carefully lower the float into the main housing with the torque generator up, the B-facing the assembler and +SRA to the left.

C. Insert the dummy stop pin A-92284 into the +SRA balance port, and secure it with a locking screw.

12. Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00 96 x 0.156 long fillister head screws.

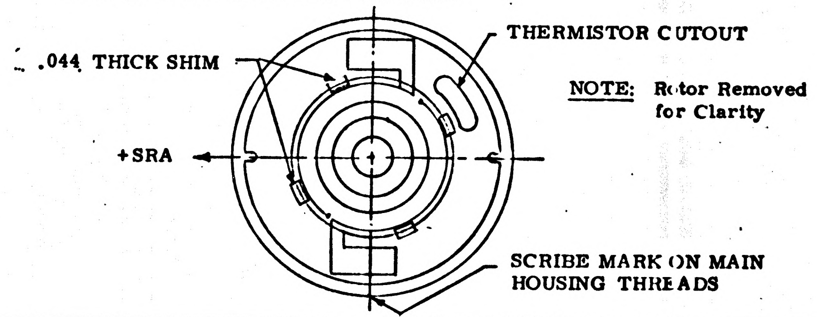
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax.

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.



NOTE: Rotor Removed for Clarity

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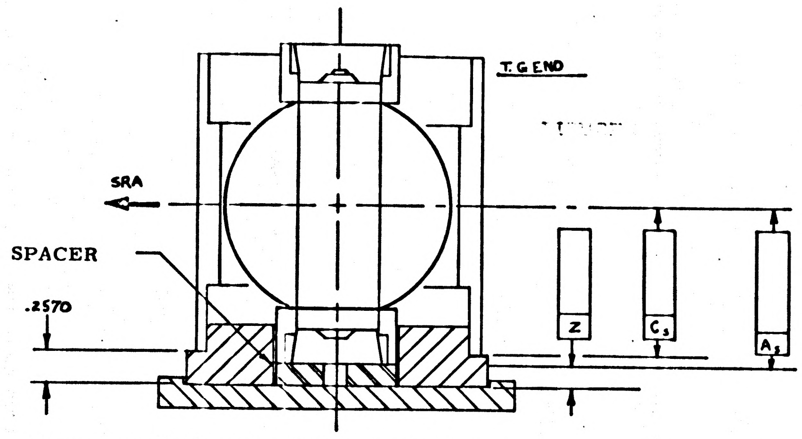
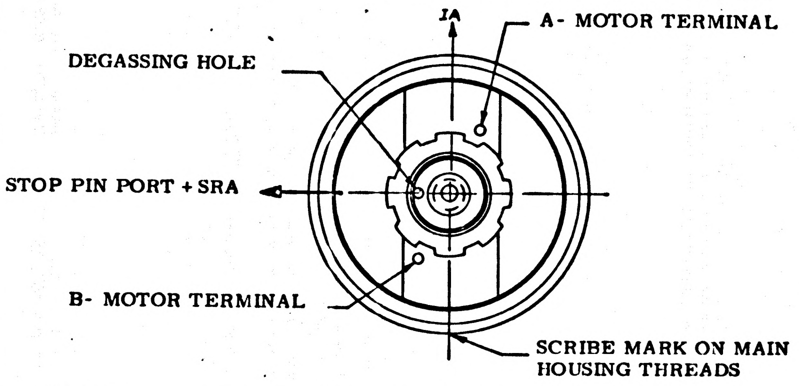


Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from figures 1 and 2

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

$$Z_s = 0.2570 + \boxed{C_s \quad} - \boxed{A_s \quad}$$



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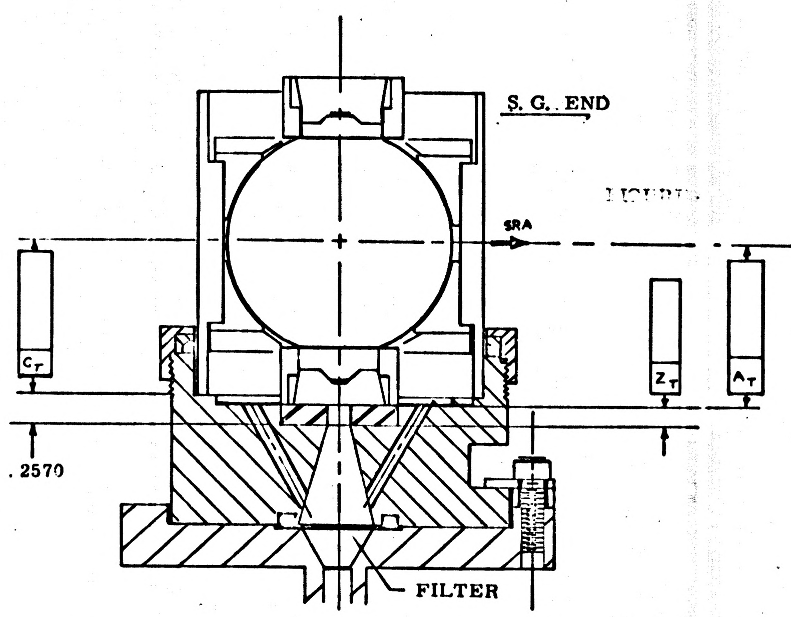
C 12.0 Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from figures 1 and 2



$$Z_T = 0.2570 + \boxed{C_T \quad} - \boxed{A_T \quad}$$

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B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring A-84086.5 and the retainer A-84086.4 over the O. D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O. D.

E. Assemble the drain block B-94086 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. Assemble the signal generator end damping block assembly.

H. Solder the flex leads to the float terminals as before.

13.0 Flushing The Instrument

The freon supply for the flushing operation is outfitted with a 0.45 micron air filter, a millipore filter holder cat. # xx40-025-00 and a Wilkerson dehydrator model #4001-2.

A. Carefully place the unit on the flushing stand base, A-123892, and tighten the toe clamps.

B. Mount the shield, A-123894, in position on the base.

C. Assemble a clean 0.45 micron filter to the millipore filter holder.

D. Place the assembly under the outlet and control the flow of fluid (PCA) precision cleaning agent into the unit so as to maintain a head of fluid, level to the top of the main housing, and continue until one (1) gallon of fluid has been flushed through the unit.

E. Remove the clamping ring, retainer and "O" ring from the T. G. end.

F. Place the Zs spacer on the S. G. rotor face, and carefully mount the first drain block into position. Invert the instrument.

G. Repeat the flushing operation "A" through "E"

H. Remove the unit from the flushing stand and insert a clean 0.80

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micron millipore filter. Assemble the unit to the stand as before and flush through additional fluid. (approx. one (1) quart)

I. Remove the filter and examine under a 30X microscope. If the filter shows a high dirt count, free flow another gallon of filtered freon through the unit inverting the unit during the process. Allow to drain.

*J. Insert a new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under 30X power microscope.

K. After flushing inspect both ends of unit under microscope.

14.0 Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in filtered freon, followed by a thorough vacuuming.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 70 microinches.

E. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

F. Using wrench (A-122186) back pivot off 1/8 turn.

G. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

H. Remove the fixtures from the torque generator end.

generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

* Note: Particles shall be sized to ascertain that particulates do not exceed the following requirements.

Allowable No. of Particles	Particle Size Range
3	5-25 microns
0	>-25 microns

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15.0 Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet 13.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut. Lubricate "O" ring with a very small amount of BFC. Omit this step if simulated + IA balance adjuster is used.

16.0 Dry Centering

A. Dry center the instrument as per MC 25-854.

Note: If tooling simulating + IA balance adjuster has been used:

1.0 Remove tooling simulating + IA balance adjuster.
2.0 Insert the + IA balance adjuster, the "O" ring, and pressure washer, and secure with the locking nut.

18.0 Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 50 in-lbs. Invert unit and repeat above procedures.

19.0 Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak= 0.1 x 10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page #13.

Bellows Measurement

A. Measure bellows overall length and record below.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: 18 March, 1968

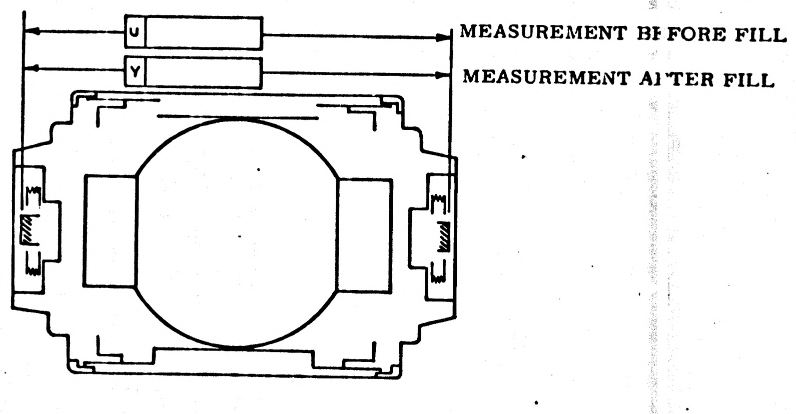
TDRR 36402 JUN 21 1968

MC 25-853

SHEET 14 OF 15

CB 19. Bellows Measurement

D A. Measure bellows overall length and record below.
B. Weigh the unit and record. (optional)
C. Fill the instrument as per MC 25-816.
D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding
Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)-- ☐ Grams

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PREPARED BY: C. J. Cormier
DATE: 18 March, 1968

TDRR 36402 JUN 21 1968

MC# 25-853

SHEET 15 OF 15

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO T_Y					
S_H TO S_L						T- TO T_Y					
S_L TO SSQ1 SEC						T_Y TO T_C					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT

A- TO A+					
B- TO B+					
A- TO B-					
A+ TO B+					

APOLLO II IRIG Specification
MC 25-855 REV J
Release Date 25 Nov. 1964
Release Revision A
Class A Release
TDRR 14531

FLOAT ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
4-30-65	B	18829.	1, 4, 5	WK.	WJR
3/21/68	C	35603	4, 5	DRK	
8/1/68	D	36614	1, 2, 3, 4, 5, 7 and 8	DRK	
1/31/69	E	37288	1-3	MGM EA	WLS
4/21/69	F	37524	3, 6	MGM EA	WLS
6/17/69	G	37671	All	MGM EA	MH
7/8/69	H	37702	6, 7	RM, EA	MDH
4/15/70	J	38096	1,2,3,4,5,6 and 7	MGM JS	MDH

TP#11938

This MC specification consists of page i ~~to~~ ____ and 1 to 9 inclusive.

FLOAT ASSEMBLY PROCEDURE

Examine the inspection report accompanying the float, and bring to the supervisor's attention any deviation from the print.

The wheel shaft, and float hemispheres must be matched for a .000025"±.000015" interference fit.

1.0 Record the O.D. of the wheel shaft. This information will be found in MC 25-605.

+SRA ______________ -SRA ______________

Record the I.D. of the float hemisphere bores.

+SRA ______________ -SRA ______________

Average Interference

+SRA ______________ -SRA ______________

2.0 Lap the #12-72 and #5-40 balance weights, also the #2-56 sealing screw to insure a smooth fit. Extreme care should be taken with # 12-72 balance weights so that no looseness occurs. Lap the conical seat of the degassing hole for proper seating of the ball, using a piece of pointed peg wood charged with 305 A lapping compound. With a dummy shaft #A-92245 lap the #5-40 threads of the bushings. Refer to MC-400 for handling beryllium.

3.0 Carefully examine the jewel and end stone area under a microscope for any residual adhesive. This area can be cleaned using a .040" drill blank charged with #.305 A lapping compound.

4.0 Clean the #5-40 and #12-72 Balance Weights, the two Bushings, the two Float Hemispheres, Sealing Screw, and Gimbal Assembly by brushing them in clean trichloroethylene for a minimum of three (3) minutes. Ultrasonically rinse them in clean Freon for the same time period. Clean the stator assembly by brushing it in either:

a. varsol #2 at 70° to 95°F or

b. trichloroethylene for a period not to exceed five (5) minutes at room temperature.

Rinse the part in clean Freon.

NOTE: Neither the Stator Assembly nor Stator-Gimbal Assembly is to be ultrasonically cleaned.

5.0 Weigh all the float parts and record this information on the float weight sheet.

6.0 Lightly blue the hemisphere joint tapers and check the fit with the gimbal. Do not use if circumferential contact is less than 70%. Remove the bluing with a kimwipe dampened in acetone, followed by cleaning as in step #4.0.

7.0 Examine the motor stator for exposed wires, voids, cracked potting, loose terminals, etc.

Perform electrical check. Measure and record additional information requested on motor stator process sheet MC #810. This sheet should be received with the stator.

8.0 Measure and record the following:

A) O.D. of stator ________________

B) I.D. of gimbal ________________

Subtract the gimbal I.D. from the stator O.D. and enter in "C".

C) Average interference ________________ (.0001 - .0003)

9.0 Install the motor stator into the gimbal as follows:

A. Mount the gimbal on the motor stator installation fixture base A-87424, and place on a thermostatically controlled hot plate and heat to 200°F ± 10° for about fives minutes.

B. Place the bushing A-92287 into the pressure plate.

C. Assemble the motor stator to the pressure plate A-87423.

D. Tighten the lock nut A-92286 just enough to hold the motor stator in position.

E. Using an artist's brush apply a small amount of Epon 828 adhesive (MC 25-303) to the center of the motor stator O.D.

F. Remove the gimbal and fixture base from the hot plate.

G. Place the pressure plate on the guide post of the base, and with an arbor press, carefully press the stator into the gimbal until the the stator bottoms on the base.

H. Remove fixture and check centering of the stator in the gimbal. Check continuity. (Stator should be centered to within .005")

I. Assemble the gimbal to fixture 2A3-10B198 and place in 150°F ±5° oven and cure for 1 1/2 hours minimum.

10.0 Weigh gimbal and record ________________ gms.

11.0 Grind I.D. of motor stator as per drawing 2021625.

12.0 After grinding, clean the stator by scrubbing with an acid brush while immersed in varsol (room temperature or warm 90°F ± 5°) followed a thorough rinsing in clean freon. Trichloroethylene may be used instead of varsol# 2 if the exposure time to the solvent is less than five (5) minutes at room temperature.

13.0 Inspect the motor stator for any loose potting, smeared metal, and general condition. Perform continuity check.

14.0 Weigh gimbal and record ________________ gms.

Determine the final stator weight by subtracting the weight removed by grinding from the weight of the preliminary ground stator. Record on float weight sheet.

15.0 Power Lead Installation

A. Assemble the gimbal to fixture 2A3-10B198 and place in 180°F ±5° oven for 1/2 hour minimum.

B. Apply a small amount of LCA-9 adhesive (MC 25-302) to the O.D. of two power leads and to the gimbal counter bores and insert the the power leads into the gimbal. If necessary apply additional LCA-9 to fill counter bores flush to gimbal.

Cure for one hour at 180°F ±5°.

C. Repeat step "B" on opposite end of gimbal.

D. With the gimbal still attached to fixture, fill the inside of the .063" diameter holes where the power leads exit, with LCA-9. Cure for one hour at 180°F ±5° minimum.

E. Remove from oven and fill the back side of the two remaining .063" diameter holes and cure for two hours at 180°F ±5° minimum.

16.0 Install .062" diameter ball and #2-56 sealing screw into the degassing hole and with fixture B-92248 leak check the gimbal and record. Max. leak rate 0.10×10^{-8} ATM cc/sec. Leak rate ______________

17.0 Cycle the gimbal from 40°F to 180°F four (4) times, with a dwell time of one (1) hour at the extremes. Alternate cycle +32°F to +200°F four (4) times. Releak check the gimbal. Maximum allowable leak rate = 0.10×10^{-8} ATM cc/sec.
Leak rate = ______________ATM cc/sec.

18.0 Remove the sealing screw and .062" diameter ball. Re-assemble the #2-56 sealing screw to the gimbal. Do not tighten.

19.0 Solder the four (4) power lead-ins to the motor stator terminals with 60-40 solder and 1571 Kester Flux. Clean the solder joints with trichloroethylene using an acid brush or artists brush and followed by rinsing in clean freon. Perform electrical test.

Alternate Clean: AP-20 flux remover brushing, followed by trichloroethylene brushing and subsequent rinsing in freon.

20.0 Assembly of the Wheel to the Float

A. Except for Inertia Element and Bearing Assembly, thoroughly clean all the float parts and fixtures by brushing them in clean filtered Freon. Follow by a thorough vacuuming.

B. Mount the +SRA float hemisphere on fixture B-88921 and place on a thermostatically controlled hot plate set to 350°F +15°F and allow to heat for five or ten minutes.

C. Carefully remove the wheel from glass container. With the end of the wheel marked with the balancing numbers in a downward position, carefully place the wheel onto the guide post and slide into the hemisphere until it bottoms. (Balancing numbers +SRA)

NOTE: Nylon gloves or clean finger cots to be worn when handling wheel.

D. Immediately remove from the hot plate and place on steel or brass block and allow to cool.

E. Remove this assembly from fixture. Cover the assembly with a clean 500 ml. beaker, while preparations are made for next operation.

F. Place the gimbal with +SRA up into a clean crystallizing dish and heat in oven to 180°F±5° for approximately 15 minutes.

G. Heat the -SRA hemisphere as in "B".

H. Assemble the gimbal to the -SRA hemisphere, lining up the scribe marks as close as possible.

I. Carefully assemble the wheel and +SRA hemisphere down over the guide post until the wheel is bottomed into the -SRA bore, aligning the scribe marks as closely as possible. Allow to cool as in "D".

21.0 Balancing the float in air

A. Assemble the -SRA bushing and with a bushing wrench A-92247 tighten to 3 in-lbs. Assemble the +SRA bushing using 3-in lbs. torque.

B. Place the float on the balancing fixture A-87426. To achieve balance along SRA add small pieces of masking tape to the light end of the axis, until that axis is balanced. The correct shim thickness can be determined as follows:

$$\text{Change in shim thickness} = \frac{\text{Weight to balance}}{\text{Wheel weight}} \times .990$$

C. Loosen the +SRA bushing. Remove the -SRA bushing and using the correct shim reassemble and tighten to 3 in-lbs. torque.

D. Tighten the +SRA bushing to same torque level as in "C".

E. Recheck air balance adding no more than 25 mg. of tape to achieve balance along SRA.

22.0 The float at this time is complete except for the rotors and balance weights. Weigh the float and record______________gms.

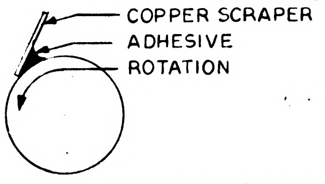
23.0 Mount the float on centers-fixture 2A3-10B186-2 and measure the runout of the stub shafts. T.I.R. should be no greater than .0002". Measure the runout of the sphere and record. Figure 3.

24.0 Refer to MC 25-803, MC 25-869, MC 25-880 or MC 25-897 for setting compliance.

25.0 Cement the float joints as follows:

A. Assemble the float to fixture 2A3-10B198 and place in a 175°F ±5° oven for 45 minutes minimum.

B. Remove the float from the oven and apply LCA-9 adhesive to one of the hemisphere to gimbal joints as follows. Work a generous application of the adhesive into the joint area with a spade oiler. Remove the excess adhesive with a copper scraper (.005 inches thick) as shown in figure 1.



Examine the joint and add more adhesive, if necessary to eliminate voids and repeat scraping operation. Any residual LCA-9 can be removed with the copper scraper and cleaned with 305A lapping compound after final cure and leak check.

C. Cure for one hour at 175°F ±5° max.

D. Repeat B for remaining hemisphere and gimbal joint cure for 2 hours at 175°F ±5°.

26.0 Filling the Float with Helium

A. Weigh the float, the #2-56 sealing screw and ball and record. ______________gms.

B. Place a #2-56 x 3/32 long S.S. sealing screw over the wrench in fixture 2A3-10D1102. Retract the wrench and screw slightly below base of the fixture and drop a .062" diameter aluminum ball on top of the screw. Locate the float properly in the fixture and draw a vacuum of 25" Hg and then admit helium to O" of vacuum. Repeat three times. Fill the float with helium to a pressure of one half atmosphere. Drive The ball and sealing screw into the degassing hole. Remove the float from the fixture and immediately check the tightness of the sealing screw, using 25 to 30 in. oz of torque.

The following alternate procedure may be used:

Install float in fixture as described in "B". Draw a vacuum of 15" Hg and then admit helium to O" of vacuum. Repeat a minimum of thirteen times. Fill float and seal as before.

C. Weigh the float and record ______________

D. Compare the weight of the float before and after filling and record the decrease in wieght which should be approximately 18 mg. ______________ gms.

27.0 Leak check and record ______________ atm-cc/sec.
Acceptable leak rate = 5×10^{-8} atm-cc/sec.

28.0 Cycle the float four (4) times from +40°F to +180°F at an approximate rate of 3°/minute, with a dwell time of one (1) hour at the extremes. Alternate cycle at +32°F to +180°F at a rate of 4°/minute.

29.0 Leak check and record __________ ATM-cc/sec.
Maximum allowable leak rate = 5×10^{-8} ATM-cc/sec.

30.0 Refer to MC 25-803, MC 25-869, MC 25-880 or MC 25-897 for float run-in procedure.

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CAMBRIDGE, MASS.

PREPARED BY: J. Publicover
DATE: February 10, 1964

MC 25-855 REV G

SHEET 8
OF 9

FLOAT WEIGHT RECORD
Apollo II IRIG
(FOR REFERENCE ONLY)

Dwg. No.	No. Reqd.	Description	Est. Wt. Sub. Tot. Grams	Est. Wt. Grams	Actual Weight Grams
2021513	4	Power Lead-in		.092	
2021634	8	Balance Weight (Final Rot. Adj.)		.740	
2021635	4	Balance Weight Spring		.018	
2021636	1	Centering Shim		.013	
2021631	2	Bushing		1.676	
2021528	1	#2-56 Sealing Screw		.037	
2021532	1	.062 Dia. Alum. Ball		.006	
		Summary of Small Parts	2.582		
2021627	2	Hemisphere		14.701	
2021628	1	Gimbal		26.051	
2021632	1	Motor Stator (Finish Ground)		18.800	
2021637	2	Rotor Assy.*		32.968	
2021701	1	Wheel Assy.		87.600	
		Wt. of Float Before Sealing	182.702		
	As Req.	Adhesive for Sealing		.100	
2021633	As Req.	Weight Reserve for Flotation Adjustment & Preliminary Balancing		1.198	
		Final Flotation Weight		184.000	

*Rotors installed at final assembly.

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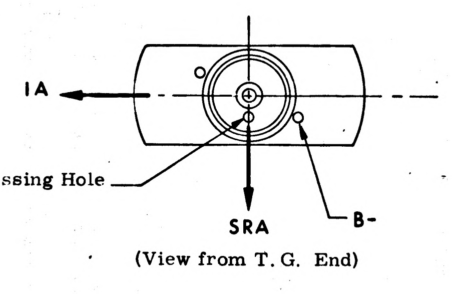
CAMBRIDGE, MASS.

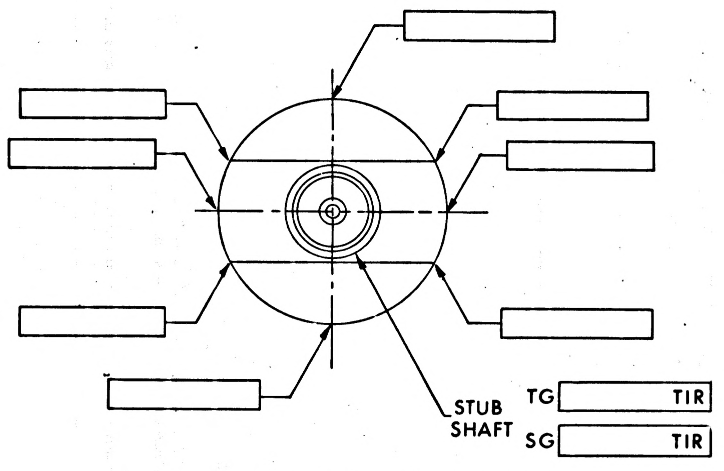
PREPARED BY: Clifford J. Cormier
Joseph Publicover
DATE:

MC# 25-855 REV G

SHEET 9
OF 9



(View from T. G. End)



Runout of float sphere to pivots.

APOLLO II IRIG Specification
MC -25-808 REV J
Release Date Nov 1 1961
Release Revision Rev E
Class ______________ Release
TDRR 14046

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
6-24-68	F	36405	1, 4		
1/21/69	G	37218	3	MGM EA	WLS
1/22/69	H	37219	3	MGM EA	RJJ
1/23/70	J	38004	2, 3, 4	9FD/AC EA	MDH

TP#11938

This MC specification consists of page 1 to ____ and 1 to 4 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 14046 NOV 4 1964

PREPARED BY: Fred Straccia
DATE: August 25, 1961
MC 25-808 REV. F
SHEET 1 OF 4

MT 1.3-305 MOTOR ASSEMBLY PROCEDURE

1. Stator Core

E Heat treat laminations B-62045 (2021674) per MC #105. Remove all burrs and throughly clean laminations according to MC 25-900. Bond laminations using B fixture #2B3-10B12 per MC 25-300. There are approximately 33 laminations to a stator core. Coat all surfaces except O.D. with Hi-Dielectric Enamel by E American Durafilm Co. (2021539) (2 coats 0.005 max. thick.).

2. Winding

Lap wind core as follows:

56 turns per coil of #35 A.W.G. aluminum wire, heavy silicone coated (2021540) 4 pole, 2 phase, 3 coils per pole per phase, 1-5 throw 2/3 pitch. Lap wind starting with phase B in slots 1-5 2-6 3-7; then phase A in slots 4-8, 5-9, 6-10. The slots are numbered C.C.W. as viewed from the side the leads come out.

3. Inserting Slot Cell Paper

D After the second coil of A phase has been wound (5-9), there will be two coil sides in slot #5. Insert slot cell paper dwg. A-107247 (20221583) in slot #5 between winding and core. This is done by compressing the winding with a wedge-shaped wooden peg away from the slot opening on both sides of the core. Compress winding under slot opening by carefully pushing through a long pointed wooden peg between the winding and core. Insert the small end of slot cell paper in this space. Pull paper through from the opposite side until it fits snug. Cut paper on both sides as close to the core as possible. Paper should lie flat and extend equally on both sides of the slot opening.

Insert slot cell papers after each successive coil has been wound.

4. Location of Winding Leads

Looking at the finished-wound stator from the winding lead side (top side) and calling the slot having the first half turn of the first coil as slot #1, number the slots C.C.W. from 1 to 24. The four winding leads are identified

Rev. D 1/17/63
Rev. E 9/10/64

Rev. B 8/31/62
Rev. A 11/1/61
Rev. C 12/20/62

---

as follows:	B+ Slot #1	B- Slot #21
	A+ Slot #4	A- Slot #24

Check for continuity of each phase, for grounds in each phase, and for shorts between phases.

Position the winding leads as follows:

A+ to Slot #12 (bottom)	A- to Slot #24 (bottom)
B+ to Slot #16 (top)	B- to Slot #4 (top)

To bring B+ and B- to their respective slot positions, weave the leads through the winding so as to follow the winding pitch. Bring A+ to Slot #12 in the same manner and insert lead under slot cell paper. Position A- by removing one half turn and looping under coil. All winding leads should come out from the inside of the stator winding at the appropriate slot position.

Cut leads to 2" lengths and strip insulation with X-Var stripper down to about 1/4" from the top of the winding end turns. Clean stripped leads with Kimwipe (soft tissue) saturated with Denatured Ethyl Alcohol. Check for continuity, grounds, and shorts between phases.

5. Tin the four winding leads per MC 25-819.

6. Soldering Winding Leads to Terminal Leads

Use four 5" lengths of #35 A.W.G. H.F. copper wire for terminal leads. Strip, clean and tin 2" of each terminal lead. Insert terminal leads under slot cell papers at the appropriate positions so that they can be soldered to the winding leads. Pigtail the tinned portion of each winding and terminal lead. Solder pigtails using the tinning procedure of MC 25-819. Cut pigtails to 1/4" and insulate with Mylar tape or shrinkable sleeving per NASA dwg 1010490-120.

NOTE: Terminal lead locations are to be on the side of the stator opposite their respective winding lead positions:

A+ Terminal (top)	A- Terminal (top)
B+ (Terminal (bottom)	B- Terminal (bottom)

7. Forming (Forming Fixture A-87414)

Use a wedge-shaped wooden peg and carefully form the O.D. of the winding on both sides so that it will clear the I.D. of top and bottom plates of forming fixture. Assemble stator to plates. Visually check assembly for pinched wires.

Form I.D. of stator on both sides so that it will clear O.D. of upper and lower supports. Assemble supports to stator and check for pinched wires. Lay the terminal leads on the top of the stator winding. Assemble forming fixture. Check for continuity, grounds and shorts between phases.

---

8. Connecting (Terminal Pins to Terminal Leads)

Strip, clean and tin the four terminal leads down to about 1/8" from the top of the winding end turns.

Clean the tinned terminal leads and four motor terminals with denatured ethyl alcohol.

Hold terminal with a pair of tweezers and place a drop of Kester soldering Flux #1571 on top of terminal. Melt a small bead of 96.5 SN, 3.5 AG solder on soldering tip. Sweat solder into terminal hole until it is completely filled.

Hand solder filled terminal with a pair of tweezers and sweat terminal down over the terminal lead to proper height. (Do not allow terminal to drop below the tinned portion of the terminal lead.) Connect other leads in the same manner. Do not cut off extra lengths of terminal leads.

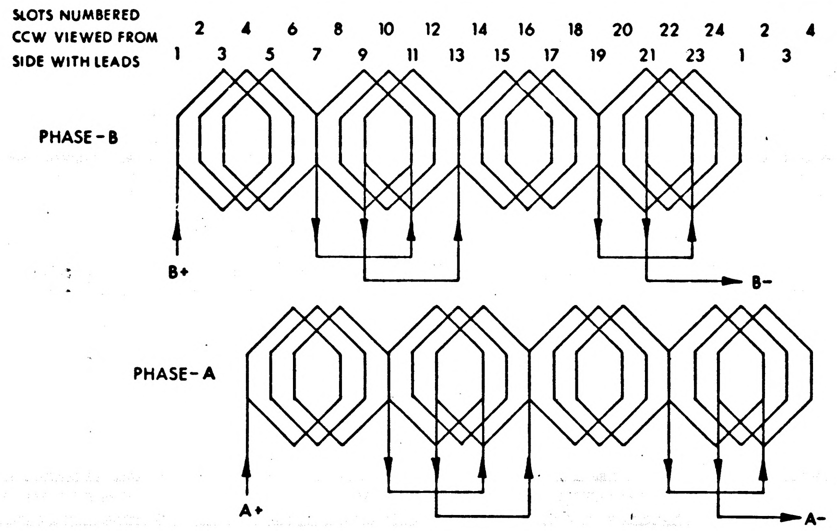
Check for continuity, grounds, and shorts between phases.

9. Potting Procedure:

9.1 For 2021632-000 and 2021632-011 assemble stator to potting mold per MC 25-504.

9.2 For 2021632-021 assemble stator to potting mold per MC 25-913.

IL 27


SLOTS NUMBERED
CCW VIEWED FROM
SIDE WITH LEADS
2 4 6 8 10 12 14 16 18 20 22 24 2 4
1 3 5 7 9 11 13 15 17 19 21 23 1 3
PHASE-B
B+
B-
PHASE-A
A+
A-

ARROWS INDICATE DIRECTION OF WINDING

WINDING PROCEDURE:

1. Wind from two spools using one continuous length of wire for each phase.
2. Lap wind, starting with Phase B in Slots 1-5, 2-6, 3-7, etc. Then phase A in slots 4-8, 5-9, 6-10, etc.
3. Excitation phase order A, B applied to terminals A & B respectively will produce C.W. rotation field, viewed from the A- terminal side (top).
4. Nominal DC resistance per phase at room temperature = 67Ω

4 - Poles
2 - Phase
3 - Coils/Pole/Phase
#35 - Awg Heavy Silicone Coated Aluminum Wire
56 - Turns/Coil
1-5 - Coil Throw
2/3 - Pitch

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY Fred Straccia
DATE: August 25, 1961

MC 25-808 REV J

SHEET 4
OF 4

APOLLO II IRIG Specification
MC 25-853
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Final Assembly Procedure
for Apollo II IRIG

General Preparations

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
12-21-64	B	16761	1, 2, 5, 6, 7 9, 10, 11, 12, 13	I Walz 2/24/65	[illegible]
9-20-65	C	22893	5, 6, 7, 9, 10, 11, 12	WK	[illegible]
10-8-65	D	23195	11, 12	WK	N/A
11-12-65	E	25210	10	WK	C. METZGER
9-27-67	F	34995	10, 11	PRK	
2-16-68	G	35662	2, 7, 11	PRK	
2-20-68	H	35689	1	PRK (13)	
6/21/68	J	36402	All	PRK	
12/6/68	K	37097	2	MGM EA	WLS

This specification consists of pages i to ____ and 1 to 18 inclusive.

Final Assembly Procedure for 25 Apollo II
IRIG General Preparations

It is very important to maintain a high level of cleanliness in all phases of the final assembly. The work area, preferably a laminar flow cabinet, should be thoroughly cleaned and all unnecessary tools, fixtures, etc. should be removed. It is also very important that the tools and fixtures to be used in this operation be thoroughly cleaned.

All parts and assemblies brought into the area should be in clean glass covered containers. Do not use plastic boxes or bags. Clean finger pots or gloves should be worn during the final assembly, and a vacuum line should be available and constantly used during this operation. All turn-around sub-assemblies and parts previously exposed to (BFC fluid) damping fluid shall be cleaned per ATP 2021500, MC 25-902.

1.0 Sub-Assemblies and Parts to be Demagnetized

A. All magnetic parts prior to final assembly.
B. Float Assembly, Dwg. 2021619.
C. End housing assemblies, Dwg. 2021663 and 2021649.

2.0 Float Preparation

A. Screw the carbide pivot 2A3-10A113 2 into one of the #12-72 balance ports.
B. Assemble the rotors to the float to insure proper seating.
C. Remove the rotors and apply a small bead of Epon 828 adhesive per MC 25-303 to the center of the stub shaft covering approximately a 60° arc at 90° to the #5-40 tapped holes.
D. Reassemble the rotors and slide into position with a slight rotational motion to insure proper spread of the adhesive.
E. TG rotor should be aligned per MC 25-618 step A.11.
F. Place the float on the rotor aligning fixture C-112976 and check for correct alignment. Wipe off any excess adhesive.

G. Place assembly in oven and cure for 1 1/2 hours minimum at 150° ± 5°F.
H. Carefully mount the float in the adjustable centers, fixture 2A3-10B186-2 and check the rotor runouts and record on page 16.
I. Insert the reference pin, 2A3-10A124.3, into the +SRA balance port. With a depth micrometer measure and record the requested information as indicated in figures 1 and 2. Sheet 15.
J. Thread one (1) of the # 12-72 balance weights into the float bushing until it bottoms.
K. Place the balance weight spring into position (arch side up) and thread the second weight to its maximum travel, and if necessary, back off to achieve alignment. Check the tightness of the weights with a torque watch applying 5-8 in.oz. of torque.*
L. Repeat steps "J" and "K" for the remaining weights.
M. Determine the number of turns available and set the +SRA and +IA weights at their mid-position. Bottom and lock the -SRA and -IA weights.

Weight the float and record ____________ grams.

3.0 Flotation and Rotational Balance

Determine the neutral buoyancy, end for end, and rotational balance as follows:

A. Place the float in a 135°F ± 5° oven for a minimum of fifteen minutes.
B. Fill the flotation tank, 2A3-10C165.1, with flotation fluid, MC 25-614.
C. Adjust the temperature of the tank to 137°F ± 2°F to achieve a density of 2.3850 ± .0.2 gm/cc. Depending on the density of the lot of the fluid to be used to fill the unit, select the appropriate plummet and check the density of the flotation fluid, which should be in the range as indicated above.

* Note: This value is (wet) torque, obtained by lightly lubricating weights with BFC fluid, followed by cleaning in prescribed manner.

D. Add # 5-40 balance weights to the float stub shaft to bring the float weight to 183.8 grams.
E. Place the float carefully into the fluid, put the cover on the tank and draw a vacuum for approximately 5 minutes. Remove the cover and observe the float which should break the surface of the fluid. Add weight to the float (in the tank) in the form of U-shaped pieces of 60-40 virgin solder, placed over each stub shaft until the float is submerged and floating level, but not touching the bottom of the tank.

Remove the float and solder weights from the tank, and thoroughly clean the solder weights in freon. Weigh the solder weights. n rinse. Weighthe solder weights.

Weight in air of solder on holder at TG end ____________
Weight in air of solder on holder at SG end ____________

Compute the effective weight of the solder in fluid at each end by multiplying the above weight in air by 0.782 and dividing by the appropriate correction factor of the metal which is to be used (see below) and record in the space provided.

Stainless Steel	0.698
Mallory 1000	0.858

Weight (in air) added to TG end ____________
Material ____________
Weight (in air) added to SG end ____________
Material ____________
Total float weight in air ____________

F. Return to the flotation tank. Cover the tank and degas the fluid until the air trapped in the float is removed.

Observe the neutral buoyancy and end for end balance. If the buoyancy and end for end is within 15 mg, it will not be necessary to make any further adjustment.

G. Place the float in the rotational balance fixture B-84056, allowing some end play and heat in a 137°F ± 5° oven for 15 to 20 minutes. Place assembly back into the tank and degas for approximately 5 minutes.

H. Align the float so that the SRA is horizontal and observe the direction of rotation. Adjust the # 5-40 balance weights to correct unbalance. Repeat this procedure along the IA axis. Re-examine the SRA axis because some cross coupling may have occurred.
To check the accuracy of the rotational balance, turn the Stainless steel # 12-72 balance weights out one half turn. The float must be sensitive to this unbalance. This is done on both axes.

I. Remove the float from the tank and thoroughly clean by immersing in warm varsol 90°F ± 5°. Follow by rinsing in warm filtered freon. Repeat this cleaning procedure two-three times, changing the fluid, after each cleaning.

J. Vacuum bake the float for a minimum of 16 hours at 150°F ± 5°.

K. Leak check and record ________ atm-cc/sec.
Acceptable leak rate 5×10^{-8} atm cc/sec.

L. Store this assembly in a clean glass container until required.

4.0 Main Housing Preparation

A. Lap the balance adjuster locking screws and the 00-96x5/32 long screws using 305A lapping compound.

B. Examine the balance adjusters and "O" ring pressure washers, paying particular attention to the areas that come in contact with the "O" ring. These areas should be highly polished. Select four "O" rings and carefully inspect for imperfections, lint or any imbedded foreign matter. Refer to MC-400 for handling beryllium.

5.0 Preparation of End Housing Assembly

A. Lap the #3-56 spline head screw to the end cap, using 305-A lapping compound.

B. Lap the conical seat in the end cap stud with a piece of sharpened pegwood charged with 305-A lapping compound. Clean all the parts ultrasonically in trichloroethylene for five minutes minimum. Follow by an ultrasonic rinse for the same time period, in clean freon.

C. Assemble the end cap gasket, the end cap, pressure washer and locking nut to the end housing, and torque to 50 in. lbs. using fixture B-87345. Insert the 0.078" aluminum ball and #3-56 seal screw and torque to 28-30 in. oz. Leak check. Maximum allowable leak rate is 1.0×10^{-8} ATM cc/sec.

D. Remove the sealing screw and ball (do not re-use the ball) and end cap parts.

E. Assemble the end caps to the extension fixture and repeat cleaning as in step "B".

F. Place the end caps into a clean glass covered container, and store in a 150°F ± 5° vacuum oven until required.

G. Procure the thermistors per 2021518.

H. Solder the thermistor lead to the buttons on the end housing with 60-40 solder and Kester 1571 flux. Clean the solder joints with an acid brush and trichloroethylene followed by a rinsing in clean freon. The thermistor should be flush against the potting and between the buttons.

I. Carefully inspect the end housings under a 30x microscope for loose or flaking compound, metal smear, flux residue, quality of the two (2) contact buttons, cracked potting and cleanliness of the two (2) fill holes.

J. Thoroughly clean the end housings by scrubbing while immersed in warm varsol 90°F ± 5°. Rinse in warm freon.

K. Store the assemblies in a 150°F ± 5° vacuum oven for a minimum of 150 hours.

6.0 Damping Block Preparation

A. Clean the damping block ultrasonically in trichloroethylene for three (3) minutes, followed by an ultrasonically rinsing in freon for three (3) minutes.

B. Check the fit of the damping blocks to the main housing.

C. Using a watchmaker's staking set (K & D) or some other suitable tool, stake the springs to the spring mount with the eyelets. If staking tool is used for this operation, satisfactory results will be obtained if the following punches are used.

A. K & D #100 round nose for spreading.
B. K & D #106 flat for staking eyelet to counterbore.
C. K & D #108 flat for staking eyelet head.

D. After staking, the spring should be checked to insure no rotational movement is possible. Also, the spring should be flexed by depressing with a piece of pegwood and the tab observed to insure no visible motion.

E. Tin the flex lead tabs side and top, using 60-40 solder and 1571 flux. Clean with trichloroethylene and artist brush, followed by freon rinse.

F. With an artist brush, apply a coat of Epon 828 (as per MC 25-303) to the back side of the spring mount.

G. Place the spring mount into position on the damping block, and assemble to fixture B-87304. Cure per MC 25-303.

H. Remove from fixture and allow to cool. Examine assembly, checking for excess cement and proper alignment of spring mount to damping block.

7.0 Flex Lead Preparation

A. Wind a 36-inch length of flex lead material (85% silver, 15% copper 0.0005" wide x 0.007" thick) on fixture C-145264. Heat treat as per MC #106.

B. Carefully remove the heat treated flex lead material from the fixture and cut the coil into 260° segments. Examine each lead, discarding all those that are distorted.

8.0 Attachment of Flex Lead to Spring

A. Mount a damping block assembly to fixture B-92316.

B. Apply a small amount of Kester #1571 flux to the side of the flex lead tab. Place one end of the flex lead along the side of the tab.

C. Lay a piece of flat pegwood across the center of the flex lead.

D. With a 37 1/2 watt soldering iron, apply heat to the top of the flex lead tab, just long enough to melt the solder and form the joint. Clean off excess flux, with trichloroethylene and a #2 artists brush. Finally clean joint with freon and artist brush.

E. Repeat A thorough D for the second damping block.

9.0 Air Gap Measurements

A. Air gap must be calculated per MC 25-620 prior to final assembly of unit.

10.0 Assembly of the Float into the Main Housing

A. Select the correct spacers A-84086.2 from the master set. Determine the thickness of the spacers (Dimensions Z_s and Z_t) as indicated in figures 3 and 4. Place the spacer Z_s in the support block A-118435.

Note: Leak check and electrically check the float and end housing assemblies prior to final assembly. In addition, all unit parts, tools, and fixtures should be rinsed in clean filtered freon, followed by a thorough vacuuming during the various stages of this operation.

Rinse the main housing in filtered freon. Place the main housing on the support block with the signal generator end down and the scribe mark facing the assembler.

B. Carefully lower the float into the main housing, with the torque generator up, the B-facing the assembler and +SRA to the left.

C. Insert the dummy stop pin A-92284 into the +SRA balance port, and secure it with a locking screw.

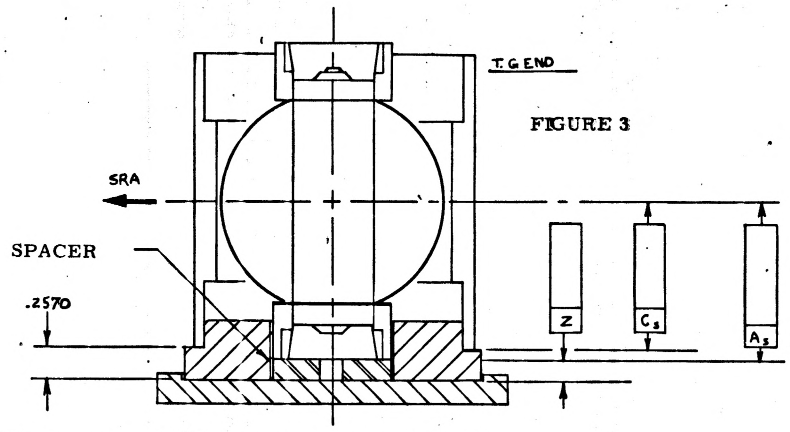
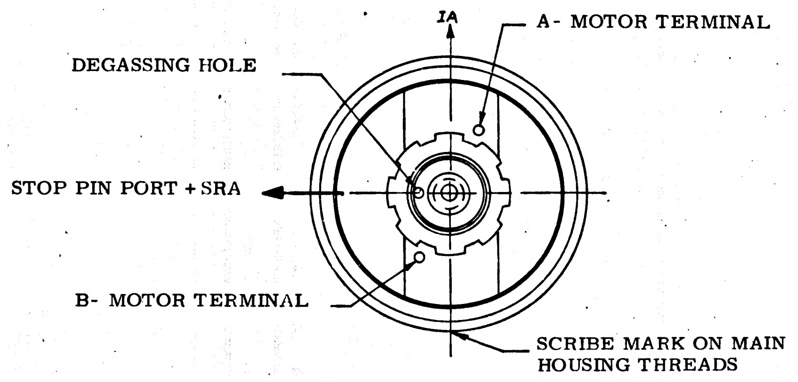


FIGURE 3

Dimensions "C" are obtained from MC 25-856.
Dimensions "A" are obtained from figures 1 and 2

To center the float in the main housing, determine the spacer thickness Z_s as indicated below.

$$Z_s = 0.2570 + \boxed{C_s} - \boxed{A_s}$$



D. Insert the +IA (0.181 long) balance adjuster and secure it with locking screw and pressure washer. Tooling simulating the balance adjuster may be used instead of the actual hardware for purpose of assembly until dry centering has been accomplished.

11.0 Torque Generator End Damping Block Assembly

A. Assemble the torque generator end damping block assembly, aligning the spring mount in the main housing as shown in figure below.

B. Fasten this sub-assembly to the main housing with the #00-96 x 0.156 long fillister head screws.

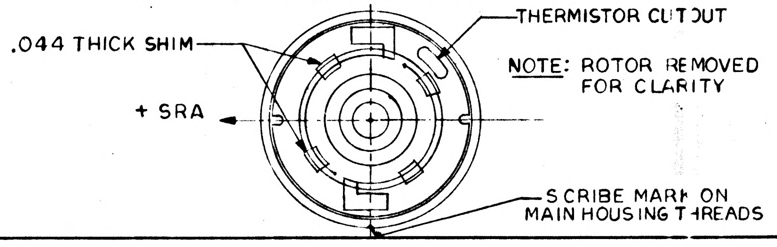
C. Use the two shims A-87335 to support the weight of the flex lead as shown below.

D. Apply a small amount of #1571 Kester flux to each float terminal.

E. To fasten the flex leads to the float, place the soldering iron on the back side of the float terminal just long enough to melt the solder and form the joint.

Remove one flex-lead shim and position the remaining one at the center of the flex lead. With the soldering iron, touch the power lead again, allowing the flex lead to relax. ~~Remove excess flex lead ribbon.~~

Check the continuity between the float terminal and the flex lead tab. Clean excess flux with trichloroethylene and #2 artist brush. Finally clean joint with artist brush and freon.


THERMISTOR CUTOUT
.044 THICK SHIM
+ SRA
NOTE: ROTOR REMOVED FOR CLARITY
SCRIBE MARK ON MAIN HOUSING THREADS

12.0 Signal Generator End Damping Block Assembly

A. Determine the support block spacer (Z_T) as shown below.

Dimensions "C" are obtained from MC 25-856.

Dimensions "A" are obtained from figures 1 and 2

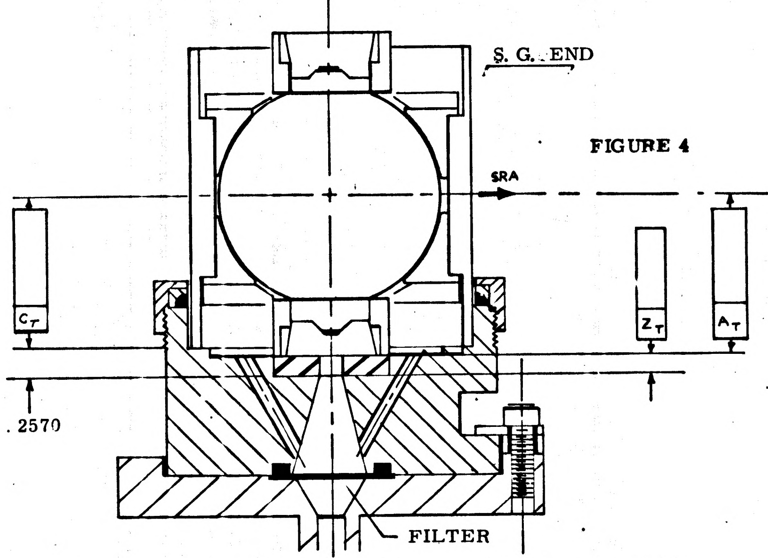


FIGURE 4

$$Z_T = 0.2570 + \boxed{C_T} - \boxed{A_T}$$

B. Place the support block spacer (Z_T) on the torque generator end rotor face.

C. Assemble the clamping ring 115742 and the retainer 115741 over the O.D. of the main housing.

D. Place a #914-42 (PRP) "O" ring over the main housing O.D.

E. Assemble the drain block 115740 over the spacer and into the main housing. Screw the clamping ring to the drain block and tighten. Carefully invert the instrument.

F. Remove the plate, support block and the spacer from the signal generator end.

G. ~~Repeat steps "A" through "D" of 8.0 for S.G. damping block, and assemble to main housing.~~

H. Solder the flex leads to the float terminals as before.

13.0 Flushing The Instrument

The freon supply for the flushing operation is outfitted with a 0.45 micron air filter, a millipore filter holder cat. # xx40-025-00 and a Wilkerson dehydrator model #4001-2.

A. Carefully place the unit on the flushing stand base, A-123892, and tighten the toe clamps.

B. Mount the shield, A-123894, in position on the base.

C. Assemble a clean 0.45 micron filter to the millipore filter holder.

D. Place the assembly under the outlet and control the flow of fluid (PCA) precision cleaning agent into the unit so as to maintain a head of fluid, level to the top of the main housing, and continue until one (1) gallon of fluid has been flushed through the unit.

E. Remove the clamping ring, retainer and "O" ring from the T.G. end.

F. Place the Zs spacer on the S.G. rotor face, and carefully mount the first drain block into position. Invert the instrument.

G. Repeat the flushing operation "A" through "E"

H. Remove the unit from the flushing stand and insert a clean 0.80

---

micron millipore filter. Assemble the unit to the stand as before and flush through additional fluid. (approx. one (1) quart)

I. Remove the filter and examine under a 30X microscope. If the filter shows a high dirt count, free flow another gallon of filtered freon through the unit inverting the unit during the process. Allow to drain.

*J. Insert a new filter and repeat flushing procedure, until no more than 2 or 3 particles are visible under 30X power microscope.

K. After flushing inspect both ends of unit under microscope.

14.0 Assembly of Signal Generator End Housing to Main Housing

A. Rinse the end housing in clean filtered freon, followed by a thorough vacuuming.

B. Carefully lower the end housing into the main housing, visually aligning the scribe marks on the end housing and main housing.

C. Assemble the clamping cap using wrench B-87333. Check to make sure that the scribe marks are aligned within 1/64".

D. Refer to MC 25-857 section VIII for pivot bore size. Select a pivot to achieve a pivot to bore clearance of 30 to 70 microinches.

E. Very carefully insert the pivot into the pivot bore (Do not rotate) until it bottoms on the end stone.

F. Very carefully thread shaft (A-122221) into the pivot, lower the ring (C-122223) into position on the end housing and clamp with clamping ring. Thread the nut (A-122183) onto the shaft until it bottoms and assemble the retainer (B-122222) to the ring.

G. Using wrench (A-122186) back pivot off 1/8 turn.

H. Carefully invert the instrument, leaving the fixtures on the torque generator end in place and set the unit on fixture A-111017.

I. Remove the fixtures from the torque generator end.

*NOTE: Particles shall be sized to ascertain that particles do not exceed the following requirements.

Allowable No. of Particles	Particle Size Range
3	5-25 microns
0	>-25 microns

15.0 Assembly of Torque Generator End Housing

A. Repeat the same procedure as used on the signal generator end.

B. Perform a complete electrical check and record on sheet 18.

C. Remove the dummy stop pin. Insert the plus SRA balance adjuster (0.235 long), "O" ring and pressure washer and secure with the locking nut.

D. Remove the locking nut and pressure washer from the IA port. Insert the "O" ring and pressure washer and secure with the locking nut. Lubricate "O" ring with a very small amount of BFC. Omit this step if simulated + IA balance adjuster is used.

16.0 Dry Centering

A. Dry center the instrument as per MC 25-854.

Note: If tooling simulating + IA balance adjuster has been used:

1.0 Remove tooling simulating + IA balance adjuster.
2.0 Insert the + IA balance adjuster, the "O" ring, and pressure washer, and secure with the locking nut.

17.0 Installation of End Cap Assemblies

A. Carefully place the instrument in the end cap assembly fixture C-87345. Place the end cap gasket into the end housing. Insert the end cap assembly, washer, and end cap clamp. Tighten the end cap clamp to 50 in-lbs. Invert unit and repeat above procedures.

18.0 Leak Checking the Unit

A. Leak check the unit using fixture 2A3-10C115, paying particular attention to the balance adjuster ports. Leak Rate=
Maximum Allowable Leak= 0.1×10^{-6} ATM-cc/sec.

B. Perform complete electrical check and record on page 18.

19.0 Bellows Measurement

A. Measure bellows overall length and record on sheet 17.

FLOAT MEASUREMENTS

TORQUE GENERATOR END

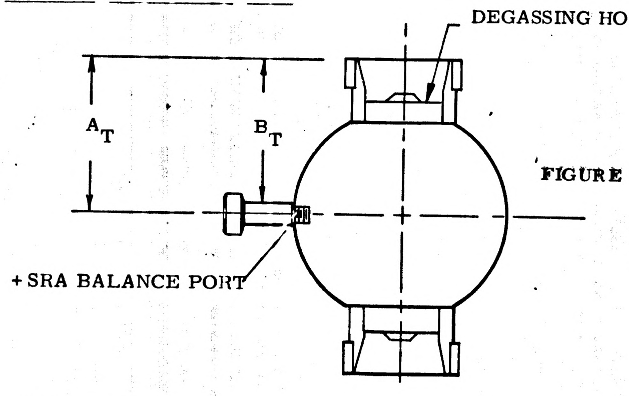


FIGURE 1

A_T ☐ = B_T ☐ + .1250

SIGNAL GENERATOR END

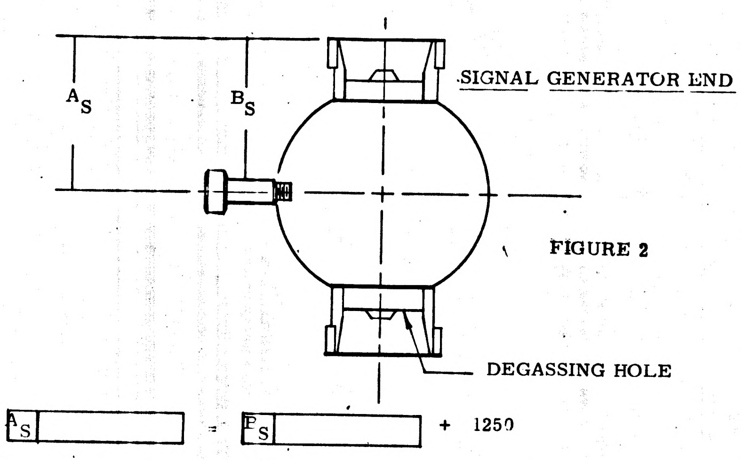


FIGURE 2

A_S ☐ = B_S ☐ + 1250

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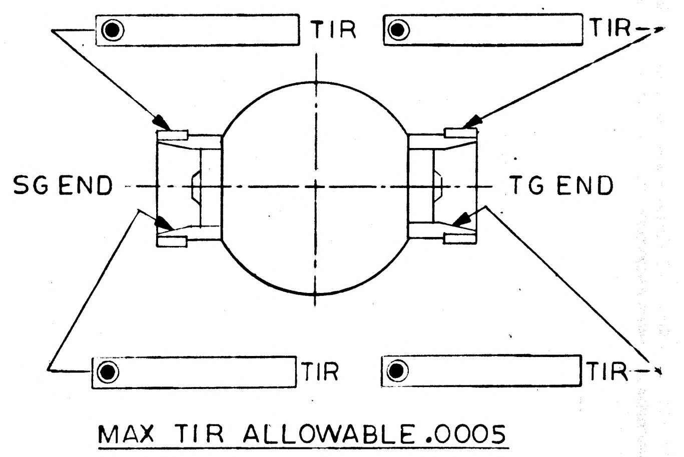
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: 18 March 1968

MC 25-853
Rotor Concentricity Record Sheet

SHEET 16
OF 18



MAX TIR ALLOWABLE .0005

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
Clifford Cormier
DATE: 18 March, 1968

MC 25-853

SHEET 17
OF 18

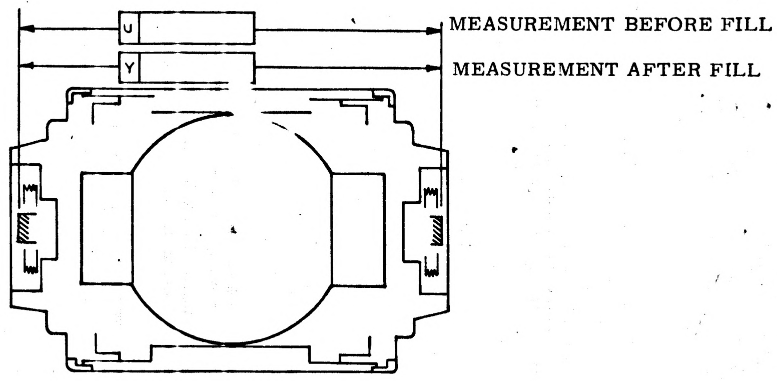
CB 20.0 Bellows Measurement

A. Measure bellows overall length and record below.

D B. Weigh the unit and record. (optional)

C. Fill the instrument as per MC 25-816.

D. Calibrate the thermistors per MC 25-800.



D Weight of unit before fill (optional)--- ☐ Grams

D Weight of unit after fill (optional)---- ☐ Grams

Shrouding

Shroud per MC 25-852

Bellows Measurement Before Shrouding ------- ☐

Min. bellows extension before shrouding = 0.130" Total

D Weight of unit after shrouding (optional)-- ☐ Grams

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CAMBRIDGE, MASS.

PREPARED BY: C. J. Cormier
DATE: 2/7/64
18 March, 1968

MC# 25-853

SHEET 18
OF 18

ELECTRICAL CONTINUITY CHECK

UNIT #

B

S.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING	T.G. END	BEFORE ASSY	AFTER ASSY	AFTER DRY CTR	AFTER SEALING	AFTER FILLING
P_L TO P_H						T+ TO Ty					
S_H TO S_L						T- TO Ty					
S_L TO SSQ1 SEC						Ty TO Tc					
S_L TO SSQ2 SEC						R_H TO R_L					
S_L TO S_{CT} SEC						BC_1 TO BC_2					
MS(3-2) TO COMM											
MS(4-5) TO COMM						MS(3-2) TO COMM					
MS(7-6) TO COMM						MS(4-5) TO COMM					
MS(8-1) TO COMM						MS(7-6) TO COMM					
THER TO THER						MS(8-1) TO COMM					
						THER TO THER					
ALL PINS TO CASE						ALL PINS TO CASE					

MOTOR CIRCUIT

A- TO A+					
B- TO B+					
A- TO B-					
A+ TO B+					

APOLLO II IRIG Specification
MC 25-803 L
Release Date 25 Nov. 1964
Release Revision H
Class A Release
TDRR 145321

Mod 2 Wheel Assembly Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
5-12-65	J	19187	All Pages	WLH	WJR
[illegible]	K	32072	15	[illegible]	AGY
5/24/68	L	36393	8	PRK	

TP#11938

This MC specification consists of page 1 to___and 1 to 20 inclusive.

Rev. F 5/17/63
Rev. E 4/25/63
H Rev. D 11/30/62
Rev. C 8/24/62
Rev. B 2/20/62
Rev. A 1/5/62
Rev. J 5/12/65
Rev. H 9/2/64
Rev. G 12/2/63

MOD 2 WHEEL ASSEMBLY PROCEDURE

1. Bearing Measurement

a) Bearings are to be received in the disassembled state with a set of components, outer race with matching balls, sealed in its individual package, and oiled with Teresso V-78 (SCD 2021550) oil to prevent rust. The geometry and material of the supplied retainers are specified by print B-87362, or 2021569 packaged separately and shipped dry.

b) Clean the outer races and shaft in the ultrasonic cleaner, using varsol as the cleaning agent, then rinsing the parts in trichloroethylene and freon. The bearing races and shaft should then be examined under a microscope for surface defects and embedded particles.

c) Set up the precisionaire column and air rings, check the sensitivity and then make at least 4 measurements of the O. D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurement. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O. D. measurements are made and record this information together with the O. D. measurements. Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Average the values of the O. D. Set up the precisionaire column and air ring to measure the shaft . 180000 diameter following the procedure outlined above.

d) Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O. D. or the shaft . 180000 diameter.

e) Oil the outer races and shaft and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adaptor. The oil should be Teresso V-78 which has been taken from a bottle filled after oil filtration. It is suggested that the oil be discarded after a two month use period.

f) Seal the bearings in clean plastic bags, replace in original outer package and store until ready to use.

g) Identify the outer package with a number and record the diameters of the bearing races and shaft, together with the temperature at which they were measured, on the outside of the bearing package.

Equipment

Ultrasonic Cleaner
Plastic Bags
AMSCO Bag Sealer
E Master Gage Plugs, Class XXX (. 180000, . 180020)
Sheffield Air Ring with two small jets for measuring the . 180000-. 180030 diameter.
Sheffield Precisionaire Column, 40, 000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring . 3748-. 3749 diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
E Master Gage Plugs, Class XXX (. 3748, . 3749)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0. 45 micron Millipore Filter.

2. Inertia Element Assembly

a) Check inspection report on wheel hub, hysteresis ring and inertia rims.

b) Clean parts in ultrasonic cleaner.

c) Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (M. C. #25-603).

d) Place one inertia rim (O. D. chamfered end down) and the hysteresis ring in fixture B-87392.

e) Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F immerse wheel hub into liquid nitrogen, until temperature stabilization takes place.

f) With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

g) Let wheel hub slide over this post by its own weight.

h) Remove this assembly from fixture, and insert the second inertia rim (O. D. chamfered end down) into fixture and repeat steps d through g.

i) Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve A-87392. 5 and an arbor press by pressing against the sleeve while rotating fixture.

Rev. C 8/24/62
Rev. B 2/20/62
Rev. A 1/5/62

NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture
Depth micrometer
Thermocouple
Hot plate
Tweezers
Drake Arbor Press

3. Temperature Cycling

a) Wrap wheel assembly in aluminum foil.

b) Place in the cycling container, #2A3-10B177, evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi; seal off container and put in temperature cycling chamber.

c) Cycle the wheel assembly four times between -60°F and +200°F.

Equipment:

Cycling container
Tenney Test Chamber
Reynolds Aluminum Foil

4. Lapping Bearing Bores

a) Measure the lapping room temperature and, using the wheel assembly data sheet (M. C. 25-603), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

b) Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40, 000-1 Amplification, Model 153-40.

c) If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator should not exceed 20 microinches, and should not extend more than . 040" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

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Rev. A 1/5/62

d) Record the actual finished bore size on the wheel assembly data sheet (M. C. 25-603).

e) Place the inertia element assembly in a vacuum oven at 150°F and evacuate for one hour at full vacuum, after cleaning in ultrasonic cleaner.

Equipment

Thermometer
Sheffield Precisionaire Column, 40, 000-1 Amplification.
Model 153-40 used with small jet spindles and Class XXX Master Gage Rings
Hand Lap - 3/8" dia. x 3" long - American Lap Co.
Lapping Compound 38-1200 - U. S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Oil Co., Inc.
Zeiss Stereo Microscope
Vacuum Oven - Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner

H

5. Numbering Wheel (If Inertia Rim not previously numbered)

a) Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

b) Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e. g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries Inc., Sycamore, Illinois

6. B Dimension Measurement (Dimension over the Hub)

Using a 0. 975000 gage block and the Johansson Mikrokator S 510 E-8, measure accurately (to within 5 microinches) dimension B and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mkirokator reference block.

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Equipment

C. E. Johansson Mikrokator S510E-8
Gage blocks

7. Contact Angle Measurement by Inner Race Rotation

a) Clean bearing assemblies as in paragraph 12 M. C. 25-803. steps a and b.

b) Assemble outer races as in paragraph 13 M. C. 25-803. For this measurement tapered or stepped pocket retainers can be used for assembly convenience. Important: If tapered or stepped pocket retainers are used, insure that interference is reduced to a minimum by predenting the ball pockets, eliminating possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this measurement, these retainers must not be used in the final bearing assembly.

c) Install the shaft and the mating outer race in fixture D-95850 and rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

d) Determine the contact angle using the following formula:

$$\text{Cos } B = \frac{E}{d}\left[1 - \frac{2NE}{No}\right]$$

Where E = pitch diameter 0. 24945 (print nominal value)
d = ball diameter
No = number of inner race revolutions
NE = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

Equipment

Contact Angle Gage

8. Preload Spacer Thickness Selection

With dimension A as recorded on bearing package by manufacturer, and dimension B as measured here in section 6, determine spacer thickness by using the following simple formula:

A = B + t-65 microinches
or t = A - B + 65 microinches

where t is the spacer thickness and the 65 microinches shaft deformation is explained in section 14.

---

9. Retainer Impregnation

E

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and 30 inches vacuum for five hours, minimum, to completely remove all traces of water and solvent contents.

b) Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and 27 ± 1/2 inches vacuum, outgas the retainers and oil for approximately one hour.

d) Immerse retainers in oil and hold for an additional two hours, or until all bubbling ceases.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0. 8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for two hours.

9A. Retainer Impregnation (Alternate)

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and a minimum of 29 inches vacuum for 18 hours, minimum.

b) Remove the retainers from the oven and weigh each one within 10 to 30 minutes after exposure to the atmosphere. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and evacuate to 29. 0 to 29. 8 inches vacuum for a minimum of 1 hour.

d) Immerse retainers in oil and hold for an additional 2 to 3 hours.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0. 8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for 2 to 3 hours.

10. Retainer Centrifuge - (see Appendix A)

Equipment

International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts.

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in container assemblies #2A3-10A187-1 always keeping track of the assigned numbers, and place these assemblies in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

E

b) Remove from oven and install assemblies into centrifuge plate #2A3-10C187-1, and spin for 10 minutes at 6140 rpm (4000 g's).

c) Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps a and b.

d) Place retainers between two pieces of lens tissue and store in oven at 150°F for five hours.

e) Remove retainers one at a time from oven, reweigh, and compute absorption of individual retainer as follows:

$$\%\text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking.

W_2 = weight of retainer after centrifuging.

Acceptable oil absorption values are in the range of 2 to 5%.

E

f) Retainers shall be vacuum baked for five hours at 150°F immediately prior to bearing assembly.

10A Retainer Centrifuge (Alternate)

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in centrifuge cups, always keeping track of the assigned numbers, and place these in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

b) Remove from oven and install assemblies into centrifuge plate, and spin for 10 minutes at 4000 g's.

c) Remove retainers from centrifuge cups and clean cup assemblies ultrasonically. Replace retainers in centrifuge cups, this time with opposite faces out, and repeat steps a and b.

d) Remove retainers from centrifuge cups and wrap each one securely in lens tissue. Place in the vacuum oven for 30 minutes maximum at 150°F and 29-29. 8 inches of vacuum. Change lens tissue and repeat evacuation for 30 minutes maximum.

e) Reweigh each retainer between 10 and 30 minutes and compute the absorption of individual retainers as follows:

$$\% \text{ absorption} = (W_2 - W_1 / W_1) \times 100$$

where W_1 = original weight of the retainer after baking.

W_2 = weight of retainer after vacuum blotting.

f) If the % absorption is too high or the retainer visually appears to be excessively oily, proceed to step g.

E g) Wrap retainer securely in lens tissue and place in an oven at 150 F for 6 hours. Reweigh and compute % absorption as in step e.

h) Acceptable oil absorption values are in the range of 1.5% to 5.0%.

11. Final Cleaning

H a) Examine bearing retainers very carefully under a microscope to insure that no foreign material is present on the retainer surfaces and ball pockets; a needle and magnet can be used to remove foreign particles.

b) Clean all bearing assembly parts, except retainers, with the ultrasonic cleaner using trichloroethylene Rinse in freon until all parts are thoroughly clean, and examine under a microscope.

c) Clean wheel inertia element, spacer caps and screws using ultrasonic cleaner and examine under a microscope.

12. Outer Race Assembly

Prior to assembly prelubricate the balls as follows: Mix 500 parts of freon to 1 part of oil in a beaker and immerse balls. Vacuum dry balls and examine under 25x-30x microscope making sure that balls are clean. Assemble retainers, balls and outer races as follows:

a) Install retainer over the guide post of fixture #IA3-10B150.

E b) Place plug #A-92243 inside the retainer and insert balls in the retainer ball pockets.

c) Drop outer race over this assembly and press the outer race over the balls with a pair of bone tweezers.

NOTE: During this operation be careful to insure that balls are assembled with the corresponding outer race to prevent inproper contact angles, resulting when outer races are mated with unmatched shaft ends.

d) Assemble the second bearing by repeating steps a, b, and c.

Equipment

1) Fixture #IA3-10B150
2) Plug #A-92243
3) Bone Tweezers

13. Bearing Installation

a) Place the wheel assembly on the holding fixture #A-88948.3 with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

b) Lay the bearing marked II on the bore and with bone tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

H c) Place a spacer B-97652 or 2021667 over the bearing and use fixtures A-88948.1 and A-88948.2 to press the bearing into the bore. The force necessary to push the bearing into the bore will be in the range of 3-8 pounds (reference).

d) Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step c above, press bearing into its final position.

e) Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight.

f) Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

E g) Screw adaptor A-92246.2 into end I of the bearing shaft and holding only the adaptor, guide the shaft through the wheel bore until the shaft end marked II replaces the plug inside bearing II. The wheel now is supported by the shaft. Reverse the position of the wheel and place this assembly on the fixture.

h) Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

i) Repeat step b above for bearing number 1.

j) Select a spacer 0.0005" thicker than the calculated size and use fixture A-88948.1 and A-88948.2 to press the bearing into the bore (the use of a thicker spacer is suggested to prevent brinelling of the bearings in case of error in measurements).

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k) Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

H l) Install beryllium cap and insert four 0-80 Allen Head screws .187 long. Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum, without, however, placing any preload on the bearings.

m) Remove screws, beryllium cap, and spacer.

14. Shaft strain

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary.

The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

H a) Insert a 416 stainless steel rod (.093 diameter x 1.270 ± 0.001 long) into the .101 shaft I.D. Optional MTL: 52100 steel.

b) Assemble top adaptor #A-92246.1 to the II shaft end with the flat end inward and tighten to a torque of 0.75 in. lb (strain gage measurements at M.I.T. indicate that 0.75 in. lb or torque produce 76 microinches/inch shaft strain and correspondingly approximate 65 microinches shaft deformation).

The 65 microinches shaft strain will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adaptors and shaft will not be removed until that time.

15. Final spacer selection (Preload Fixture D-92272)

a) Assemble shaft adaptor #A-92278, to the #2 end of wheel.

b) Assemble shaft cap #A-92277 to the #1 end of wheel. In assembly of these adaptors insure that the applied torque does not exceed 0.75 in. lb.

c) Position wheel on top plate #C-94190, the chain that is attached to shaft adaptor #A-92278, should protrude through the bottom of the plate #C-94190.

d) Place clamping ring #B-94185, on top of wheel insuring that the teflon washer #A-94186 contacts the wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

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e) Attach weight pan #A-92281 to chain hanging from shaft adaptor #A-92278.

f) Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying six pounds load. Lift weight and zero meter and then gently apply the six pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

NOTE: If the difference in measurements is greater than the specified five microinches, this is an indication of inproper installation of thewheel. Loosen clamping screw and reposition wheel.

g) Remove Mikrokator tip from wheel hub and insert spacer of thickness t (see 8) and beryllium cap on wheel hub. Position the beryllium cap by inserting the #0-80 Allen head screws. At this time do not tighten the screws against the cap.

h) Place Mikrokator tip on the high point of shaft cap #A-92277.

i) Apply three pounds axial load and record the Mikrokator meter reading. This is the reference point to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point. Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

j) Using an Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation extreme care should be taken to insure that no part of the apparatus is disturbed.

k) Rotate the bearing shaft approximately 10 revolutions before recording the mikrokator deflection. If the difference between this measurement and the reference established in step (i) is within ±10 microinches, the proper preload has been achieved. If not, change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference. Repeat the measurement.

H l) Measure axial compliance by hanging one, three, and four pound weights on the shaft end and recording the displacement of the indicator from zero for each weight. These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on MC-811.

16. Dynamic Balancing (Preliminary)

NOTE: Balancing may be performed after temperature cycle (17).

a) Remove the wheel from the compliance fixture and mount in Dynamic Balancing Machine. Adjust excitation gain to turn wheel over slowly (60 rpm) approximately for one minute to lubricate the dry metal parts.

b) Dynamically balance the wheel until the residual unbalance is no greater than 0.25 dyne-cm. The corrections should be made by filing the O. D. of the inertia rims with the correction planes as far apart as possible. Prior to making balance corrections both ends of the wheel must be carefully sealed off with rubber cups to protect the bearings.

c) Examine the areas of the wheel and bearing shaft under a microscope and remove any trace of contamination. Before removing cups, clean the wheel thoroughly with suction hose.

d) Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
H Alt: Schenk Balancer Model #R-06

17. Temperature Cycling (Bearings Installed)

a) Wrap wheel in aluminum foil, and place in the cycling container, 2A3-10B177.

b) Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.

H Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere

c) Cycle the wheel assembly four times between +40°F and 130°F.

H Alt Cycle: 32°F to 180°F

d) Refer to MC 25-838 for dynamometer testing.

Equipment

H Cycling Container — Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

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18. Sealing Cap Screws

H Remove wheel from the dynamometer and place it in stand #A-88948.3. Remove Allen head screws on number one end of wheel, and insert cap centering ring #A-92244, around cap and wheel hub neck to eliminate cap run-out. With the cap now well centered, insert final 0-80 screws and tighten firmly. Remove cap holding screws one at a time, and with a very small drop of Loctite, tough the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace screw and fasten firmly.

a) With a microscope examine the area around the screw head and wipe off any excess Loctite. (Loctite will not cure if exposed to air). Repeat this procedure to all 8 screws.

H Alt: LCA-4 (2021552) may be used as a substitute for Loctite.

b) To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures #A-88948.3, A-92244.
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant
American Sealants Co., Hartford 11, Connecticut
H 5) LCA-4 per SCD 2021552

J 19. Dynamic Balancing (Final)

a) Check the final balance of the wheel as in paragraph 18 and make necessary corrections to achieve a maximum residual unbalance of 0.10 dyne-cm. Also measure and record the bearing noise level.

NOTE: This check should be made with the wheel at operating temperature as follows:

To bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O. D. of stator housing.

2) Cover the stator housing and entire rotor platform with a foil lined beaker.

3) Run the wheel at synchronous speed until the Alnor meter indicates 155° - 160°F. Wheel temperature will now be within the operating limits.

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Equipment

Micro Dynamic Balancer, Model K-1
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
H Alt: Schenk Balancer Model #R-06

20. Final Inspection

a) Place wheel under microscope and inspect for lint and dust particles.

b) Clean off with vacuum hose and repeat (a).

c) Place the wheel in a plastic bag and hermetically seal in a vacuum.

Equipment

H Zeiss Stereo Microscope
Vacuum hose
Plastic bag
AMSCO Bag Seal
} or Equivalent

21. Installation in Float

Install the wheel into the float according to the Float Assembly Procedure MC #25-810 or MC #25-855.

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

a) Assemble adapter #A-95721, firmly to the VS-10.

b) Thread lock-nut #A-92357, to the 12-72 stud until it bottoms.

c) Assemble the (-) SRA end of the float to adapter #A-95721 very carefully until it bottoms, then back the float off one full turn.

d) Fasten the float by bottoming lock-out #A-92357 firmly against the bushing, using spanner wrench #A-92359.

e) Set variable frequency oscillator at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 470-580 mv.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

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f) Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V. T. V. M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat step f three times and take the average of the resonant frequencies.

g) Using this resonant frequency and curve (sheet 20), determine the axial compliance of the wheel.

h) This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on M. C. #811 within ±0.25 microinch/lb.

i) If the axial compliance as determined in step (g) above is higher than the compliance recorded on M. C. #811, insert wrench #A-92262 in the +SRA bushing and lock wrench firmly by turning locking screw.

j) Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel installed in the float). Remove wrench #A-92262, and steps f and g. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step (g) is lower than that recorded on M. C. #811, insert wrench #A-92262, and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps f and g. It is suggested that the torque values are increased in increments of one inch-lb at a time until the required compliance is achieved.

k) With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as in steps c and d.

l) Determine the radial compliance repeating steps f and g.

m) Record both axial and radial compliances in M. C. #25-605.

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, ΔC, is equal to or less than 1.0 microinch/lb. If the term ΔC is greater than 1.0 microinches/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4°/min. max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in M. C. #811. If the compliance is outside the imposed limits, the float should be re-torqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

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H n) Using a spade oiler, or other suitable tool, apply LCA 9, (SCD 2021529) MC 25-302, to the -SRA bushing and torque to 5 inch pounds.

o) Remove the +SRA bushing and repeat the cementing operation per step n, replace the +SRA bushing and torque to 3 inch pounds.

p) Repeat steps a through m as necessary to reset compliance (Note: the torque required at this time will be higher than the initial torque).

q) Cure assembly for 2 hours at 180°F maximum.

r) Recheck compliance after cure and record on MC 25-605.

22. Final Run-In

a) Insert the thermistor holder #2A3-10A180-1.2 with the Fenwal Thermistor probe, into one of the IA balance ports.

b) Install the float into fixture #C-87364 and attach power and thermistor leads onto provided terminal strip.

c) Install top plate #A-87364.1 on top of the float.

d) Turn the power supply and heater on and set the Fenwal indicator at 137 . After one hour of wheel running, take run-down time and run-up time measurements per MC 25-834. Record these measurements and all other parameters called out on MC 25-605.

The speed and inertia of the Mod 2 wheel affect greatly the spread of the run-down measurements if taken from 24000-0 rpm. For this reason the run-down time measurements will be taken from 24000-6000 rpm and 6000-0 rpm. To do this, follow the following procedure:

1) Insure that the oscillator of the wheel power supply is 800±3 cps, and take a run-down time measurement as per MC 25-834.

H Run-down time measurements should be taken twice in every 24 hour period with a minimum of 4 hours between measurements and recorded on MC 25-605. The total wheel run-in time, including dynamometer should be 200 hours. This should include 120 hours minimum of dynamometer time and a minimum of 80 hours of float time since the last torquing or cycling.

F When the wheel has completed its run-in period the average wheel run-down time (A_F) and the rms of the deviations from average can be computed. The only imposed run-down time limit is $6_F \leq 4.0$

$$\text{where } 6_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = average run-down time to 6000 rpm.

n = number of run-down time checks (no less than 7)

T_n = RDT to 6000 rpm

NOTE: During the 80 hour minimum run-in period observe carefully the values of --a) power input, b) run-up time and c) run-down time. The run-up time should be taken with the voltage fixed at 28 volts, and it should repeat within one to ten seconds.

Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection, etc.); then, if the condition continues, reject the float assembly.

23. Delivery

Continue float assembly per MC 25-810 or MC 25-855.

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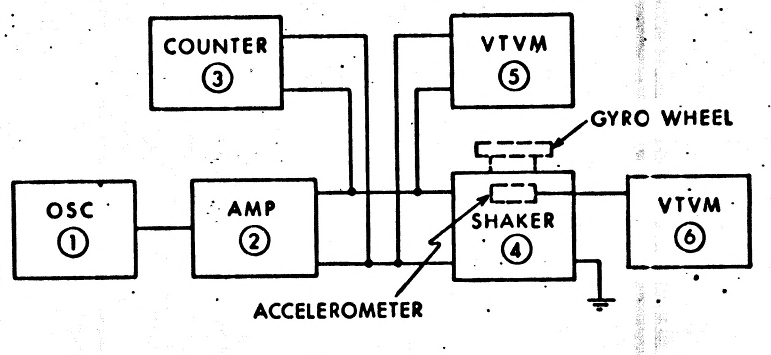
Compliance Checking Equipment.
Mod 2 Gyro



1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. V. T. V. M. - Ballentine Model 300E

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APPENDIX "A"

CENTRIFUGE

$$\text{"G" level} = \frac{w^2 r}{g}$$

w = rad/sec
r = inches
g = 386 in/sec²

$$w = N \frac{\text{Rev}}{\text{Min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times 2\pi \frac{\text{rad}}{\text{rev}}$$

$$w = N \frac{\pi}{30}$$

$$\text{"G" level} = \frac{\left(\frac{N\pi}{30}\right)^2 r}{g}$$

N = rpm
r = inches
g = 386 in/sec²

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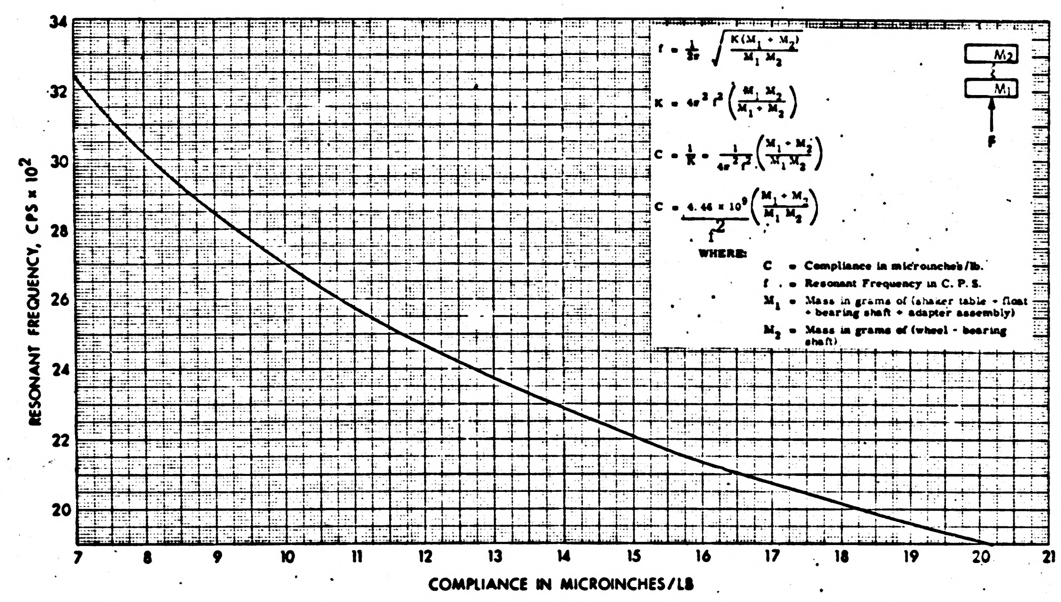

$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = \frac{4.46 \times 10^9}{f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.

f = Resonant Frequency in C. P. S.

M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)

M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

IL 27

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: J. Psyhogeos

DATE: January 5, 1962

MC 25-803

SHEET 20
OF 20

APOLLO II IRIG Specification
MC 25-890
Release Date ________
Release Revision —
Class A Release
TDRR 35599

OIL WETTABILITY TEST PROCEDURE FOR APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		

This MC specification consists of page 1 to ____ and 1 to 1 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 11, 1967

MC 25-890

SHEET 1 OF 1

OIL WETTABILITY TEST PROCEDURE FOR APOLLO II IRIG

1.0 Parts Preparation

1.1 Clean parts per MC 25-878

2.0 Preparation of Oil Drop Applicator (Dwg C-159730)

2.1 Depth at which platinum wire of oil drop applicator may be submerged below surface of V-78 oil shall be set by adjusting positioning screw to produce a drop of oil which meets requirements of Para. 3.2.

2.2 Sterilize platinum wire, 0.002" diameter, in flame of alcohol lamp

3.0 Test Procedure

3.1 While observing raceway under 40X microscope, apply drop of Teresso V-78 oil to center of raceway.

3.2 Sixty seconds after application, measure length of drop parallel to circumference using 0-10 mm reticle assembled to eyepiece. With 40X magnification, the drop shall be 2.2 to 2.8 mm in length for shaft inner races, and 3.0 to 3.5 mm in length for outer races.

3.3 Place race on holding fixture so that drop is in 12 o'clock position relative to race. Protect with dust cover.

4.0 Acceptable Test Results

4.1 After a period of 16 hours, test part shall be examined. If one-third or more of circumference of raceway is covered with lubricant, part shall be considered as wettable.

4.2 If part is not wettable, it may be subjected to acetone Soxhlett extraction for a 16 hour period. Part shall be vacuum dried after extraction procedure.

4.3 Oil wettability procedure of this specification shall be repeated. If part is still non-wettable, it shall be rejected.

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PREPARED BY: Louis Bertolami
DATE: February 25, 1964
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OF 3

Title: Unit Flotation Test

Equipment: North Atlantic Phase Angle Voltmeter VM 204 or Equivalent

Note: All voltage measurements are made with a phase angle voltmeter to insure in phase voltages are measured.

I. Unit Orientation: IA Horizontal, + SRA up

1. With the unit excited as required in procurement specification, stabilize for at least 30 minutes.

   Record the radial voltages (Sx, Sy, Tx, Ty) on chart I.

II. Unit Orientation: IA Horizontal + SRA Down

2. Allow radial signals to settle for at least 10 minutes and record voltages (Sx, Sy, Tx, Ty).

   NOTE: By varying the temperature and noting the radial voltage drift, you can determine whether flotation is above or below operating temperature. It is advisable but not absolutely necessary to have the sample temperatures on either side of flotation.

3. Change temperature approximately 3°F from normal operating temperature in the direction as determined above.
4. Repeat step 1.
5. Repeat step 2.
6. Obtain from chart I the radial voltage differences for each axis and plot on graph I.
7. Draw straight lines connecting the two temperature radial difference measurements for each axis (Sx, Sy, Tx, Ty).
8. Note the zero crossover points of each radial axis and average the temperatures indicated. This is the flotation temperature.

MC-25 850

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CAMBRIDGE, MASS.

PREPARED BY: Louis Bertolami
DATE: February 25, 1964
MC 25-850
SHEET 2
OF 3

CHART 1

GYRO ORIENTATION IA HORIZONTAL			RADIAL VOLTAGES			
			S_X	S_Y	T_X	T_Y
OPERATING TEMP.	RES._____	SRA UP				
		SRA DN				
	TEMP._____	DIFF				
APPROX. +3°F	RES._____	SRA UP				
		SRA DN				
	TEMP._____	DIFF				
APPROX -3°F	RES._____	SRA UP				
		SRA DN				
	TEMP._____	DIFF				

FLOTATION TEMPERATURE ________°F; ______Ω

MC 25 850

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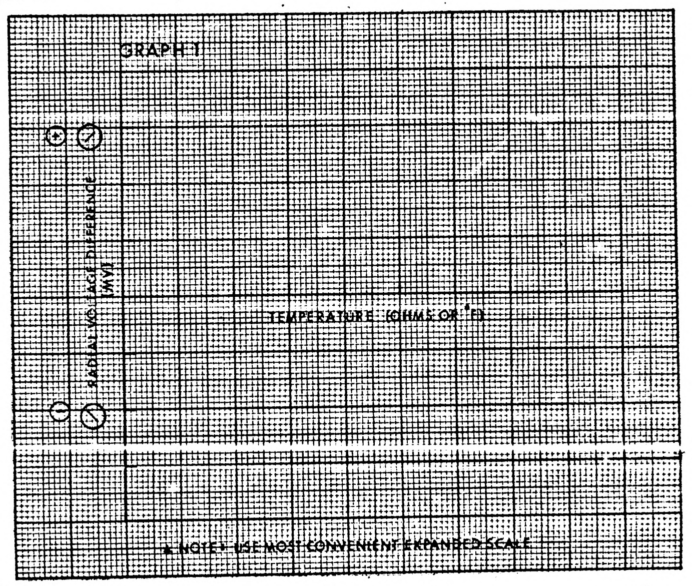
PREPARED BY: Louis Bertolami
DATE: February 25, 1964
MC 25-850
SHEET 3
OF 3



INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-881
Release Date ________
Release Revision —
Class A Release
TDRR 35599

Evaluation of Apollo II Wheel in Dynamometer

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	NASA
13 Feb 68	—	35599	INITIAL RELEASE		

TP# 11938

This MC specification consists of page 1 to ___ and 1 to 13 inclusive.

EVALUATION OF APOLLO II WHEEL IN DYNAMOMETER

1.0 General Requirements

The initial wheel evaluation will be made over a 200 hour qualification period using rundown time measurement, breakaway voltage measurement, minimum voltage to synchronous speed and torque monitoring as the critical parameters. During qualification, wheel shall be operated in ambient of one half atmosphere of helium. (Alternate: 5.0 psig helium.)

1.1 Rundown Time Measurements

The wheel qualification rundown time measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. After the first 50 hours of wheel qualification a minimum of one rundown time measurement may be taken in each 24 hour period except on weekends or holidays. The total number of rundown time measurements shall not be less than 12. Record data on MC 811.

1.2 Breakaway Voltage Measurements

The wheel qualification breakaway voltage measurements shall be made per MC 25-873 once at the beginning of the qualification period (at zero hours) and again at the end of period (at 200 hours). Record data on MC 811.

1.3 Minimum Voltage to Reach Synchronous Speed

The wheel must be capable of reaching synchronous speed at 26.6 volts. Minimum voltage measurements shall be made once at the beginning of the qualification period (at zero hours) and again at the end of period (at 200 hours). Record data on MC 811.

1.4 Torque Monitoring

The wheel qualification torque monitoring recording shall be performed during the entire 200 hour qualification period for acceptable wheels. Refer to MC 25-888 for the wheel qualification equipment specification. The recording shall be continuous except for interruptions due to scheduled rundown time measurements and interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Disposition Points

There are two formal points in time for making wheel dispositions, namely the fiftieth and the two hundredth hours of wheel operation. Fig. 1 serves to clarify the use of these two formal disposition points and indicates a wheel qualification program yield history. Dispositions at points other than the 50th and 200th hour are allowed but not required.

2.1 Fifty Hour Disposition

Within 24 hours after the completion of the first 50 hours of wheel qualification, a disposition shall be made using the following criteria.

2.1.1 Rundown Time Repeatability

If the maximum difference between the four (4) rundown time measurements is greater than 10 seconds the wheel shall be considered as having failed the evaluation.

2.1.2 Torque Monitoring Performance

The criteria for acceptance in the dynamometer evaluation lies in the interpretation of the recorded trace taken between each rundown time interval. In order to provide objectivity in this interpretation reference will be made to a number of characteristic forms of the dynamometer trace and specifications or limits imposed on each. The following identification pertains to dynamometer traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories.

2.1.2.1 Acceptable Torque Trace

The principal requirement for an acceptable wheel is performance during the monitoring period that is free of non-periodic torque variations. Fig. 2a, b, c represent acceptable torque traces with 2b and 2c indicating acceptable periodic power variations. (The variations are due in this case to ball jump in both bearings).

The maximum allowable trace width during the monitoring period for an acceptable wheel is 100 dyne-cm. The maximum allowable variation in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period compared to the level exhibited during the period between the fifth hour of running and the first wheel rundown. The allowable increase is as indicated below.

5th Hour to 1st RDT Average Dyna Torque	Allowable Maximum Trace Width at Any Time Average Dyna Torque
25	75
50	100
75	100
100	100

2.1.2.2 Provisionally Acceptable Torque Trace

There are two categories of torque variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.1.2.2.1 Torque Level Wander

Fig. 3a is typical of torque trace exhibiting a disturbance of the torque level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than once during the 50 hour qualifying period as shown in Figure 1.

2.1.2.2.2 Test Equipment Influences

Fig. 3b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory torque trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the torque trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.1.2.2.3 Oil Jogs

Fig. 3c is a typical torque trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 720 dyne-cm-minutes, the wheel shall be rejected.

2.1.2.3 Non Acceptable Torque Trace

Any torque trace resembling Figs. 4a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are squeal (Fig. 4b), intermittent squeal (Fig. 4a), low preload (Fig. 4b, c), incipient varnish failure (Fig. 4b, c, d, e, f), debris (Fig. 4b, d, e), loose wires (Fig. b, c), one ball group unstable (Fig. c, h), equipment malfunction Fig. 4i).

2.1.2.4 Other dynamometer requirements

The maximum variation in mean torque level shall not exceed 200 dyne-cm. The minimum allowable torque level shall be 800 dyne-cm (normal range 800-1800 dyne-cm, reference only)

2.2 Two Hundred Hour Disposition

After a minimum of 200 hours of wheel qualification a disposition shall be made using the following criteria.

2.2.1 Rundown Time

2.2.1.1 The RMS of all wheel rundown times (σ_D) shall be equal to or less than 3 seconds.

2.2.1.2 The RMS of the wheel rundown time (σ_D) shall be calculated using The following.

$$\sigma D = \sqrt{\frac{(T_1 - A_D)^2 + (T_2 - A_D)^2 + \ldots\ldots (T_n - A_D{}^2)}{n}}$$

A_D = Average run-down time to 6000 rpm
n= Number of run-down time checks (no less than 12)
$T_1 \ldots T_n$ = Run-down time to 6000 rpm

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the wheelassembly.

2.2.2 Breakaway Voltage Measurement Comparison

The breakaway voltage at the beginning and end of the wheel qualification period should be compared. Although no specification requirement is imposed herein, this information should be examined along with the rundown times and torque traces. Like decreasing rundown times, a significant increase of breakaway voltage is indicative of incipient bearing failure.

2.2.3 Torque Monitoring Preformance

The criteria of section 2.1.2 are to be applied to the 200 hour disposition.

2.2.4 Synchronous Voltage Measurement

Minimum voltage to reach synchronous speed at the beginning and end of the qualification period should be compared. This information should be examined along with breakaway voltage measurements, rundown times and torque traces for any indication of incipient bearing failure.

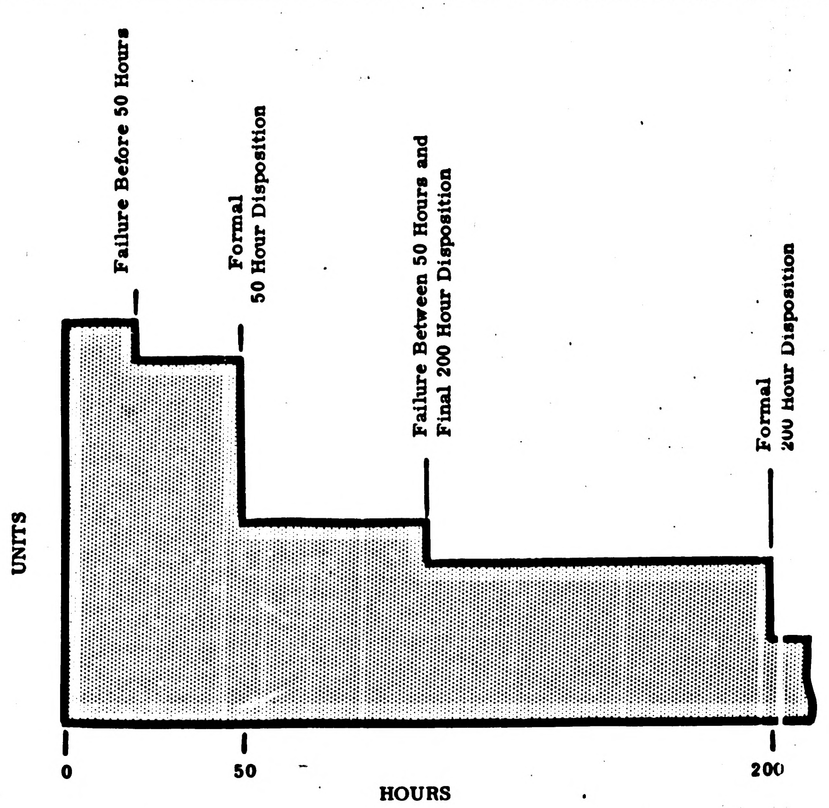


Fig. 1 Illustrative Wheel Qualification Program Yield History.

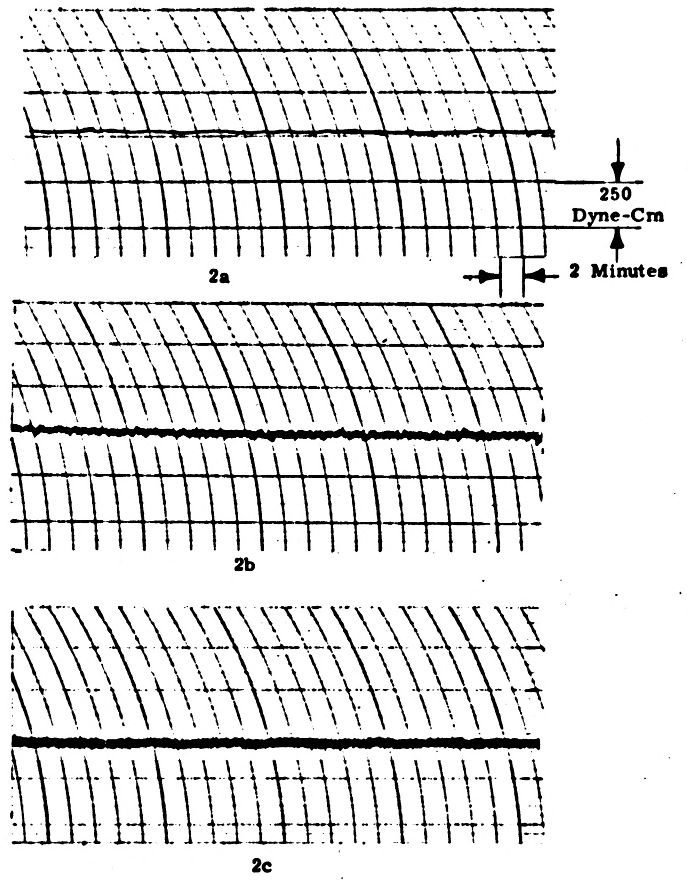
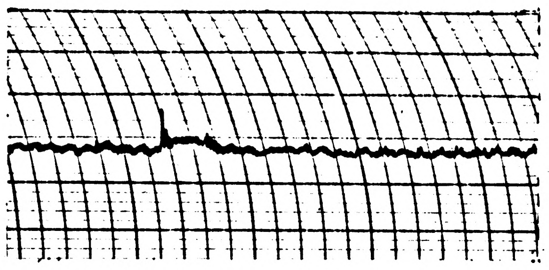


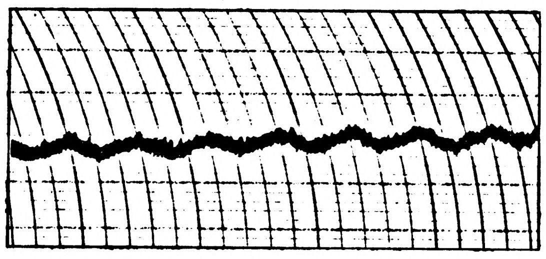
Chart Speed	6 inches/Hour
Recorder Calibration	25 D.C./mm
Recorder Time Constant	0.3 sec ± 15%

*

Fig. 2 Acceptable Torque Traces
* Chart information applicable to figures 2, 3, 4,

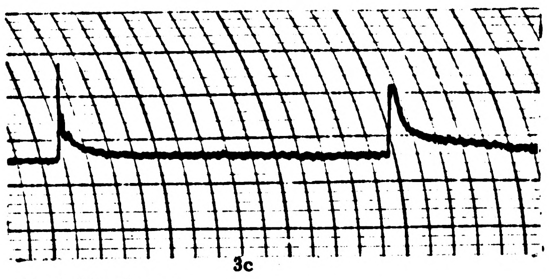


3a



3b

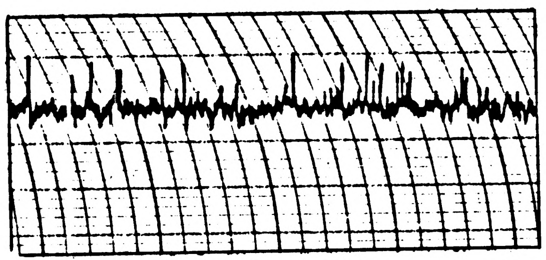
Fig. 3 Provisionally Acceptable Torque Traces



3c

Probable Cause
Oil jog

Instantaneous torque increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

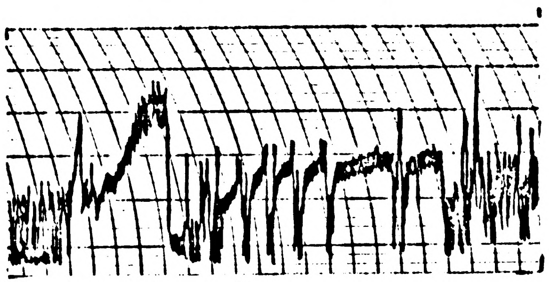


4a

Probable Cause
Excessive Oil
Intermittant Squeal

Instantaneous torque increase caused by the retainer superimposed on a rough and irregular power trace.

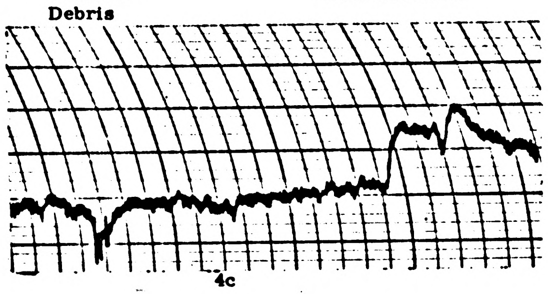
Fig. 4 Non-Acceptable Torque Traces.



4b

Probable Cause
Loose Wire
Retainer Squeal
Low Preload
Varnish
Debris

Extremely irregular torque trace that could be attributed to any or all of the listed causes singly or in combination.

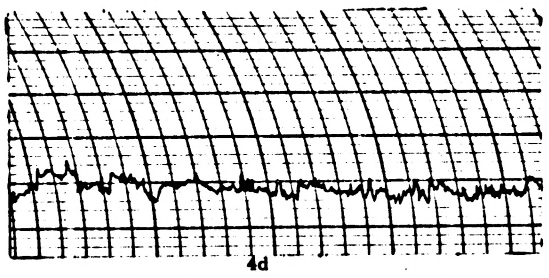


4c

Probable Cause
Varnish
Low Preload
One Unstable Ball Group
Loose Wires

Similar to 4b

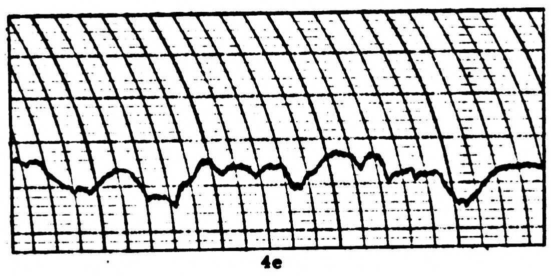
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4d

Probable Cause
Varnish
Debris

This is typical of a varnish or debris induced torque variation.

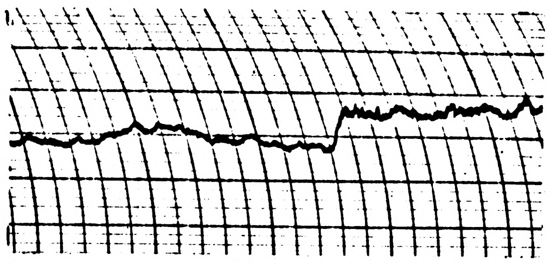


4e

Probable Cause
Varnish
Debris

A torque variation induced by debris or varnish, not as common as 4e but a positive indicator of an incipient failure.

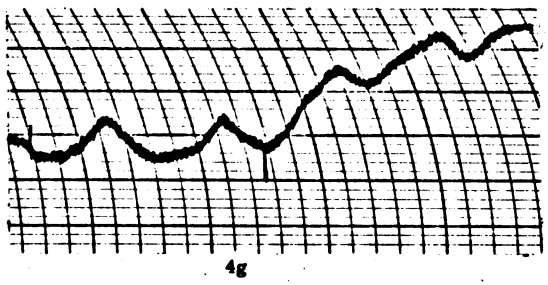
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4f

Probable Cause

Slight Varnish — Early indication of a varnish build up on one or both bearings.

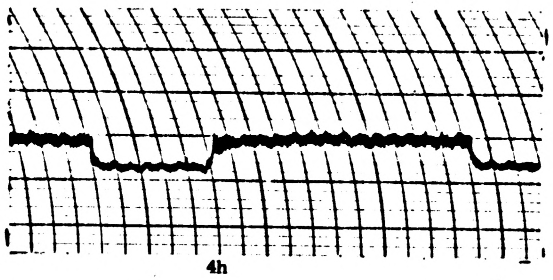


4g

Probable Cause

Varnish — This trace shows a steady increase in torque with a superimposed sinusoid attributable to a temperature control cycle.

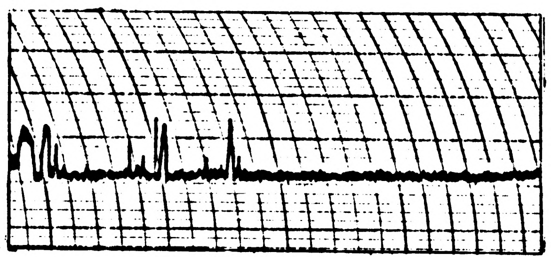
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4h

Probable Cause

One Ball Group Changing Angular Velocity — Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



4i

Probable Cause

Equipment — The torque variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

APOLLO II IRIG Specification
MC 25 -882
Release Date ________
Release Revision —
Class A Release
TDRR 35599

EVALUATION OF APOLLO II WHEEL IN FLOAT

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 Feb 68	—	35599	INITIAL RELEASE	RTBooth	

TP#11938

This MC specification consists of page i to____and 1 to 10 inclusive.

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 4 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm

n = Number of run-down time checks (no less than 8)

$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic power variations that are greater than 8 milliwatts. Figs. 1a, b, c represent acceptable power traces. 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 25 mw. The maximum allowable variation in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11	14
12	16
13	17
14	19
15	20
16	21
17	22
18	23
19-25	25

2.2.2 Provisionally Acceptable Power Trace

There are three categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 Power Level Wander

Fig. 2a is typical of a power trace exhibiting a disturbance of the power level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than twice during the 100 hour qualifying period as defined in section 1.2.

2.2.2.2 Test Equipment Influences

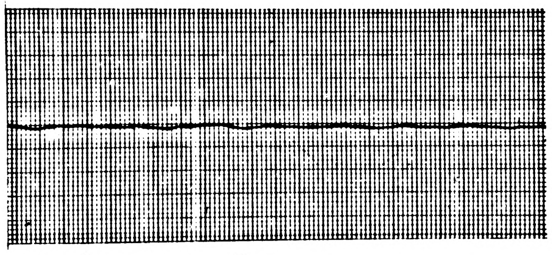
Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

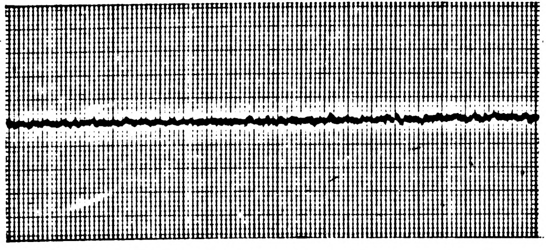
2.2.2.3 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a.) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig.3b, e), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig.3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig.3i).


1a


1b

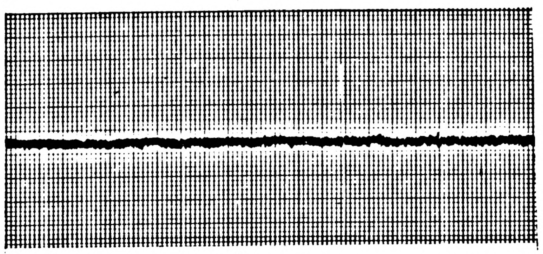
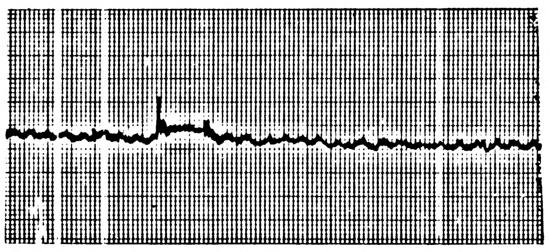

1c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sce ± 15%

Fig. 1 Acceptable Power Traces


2a

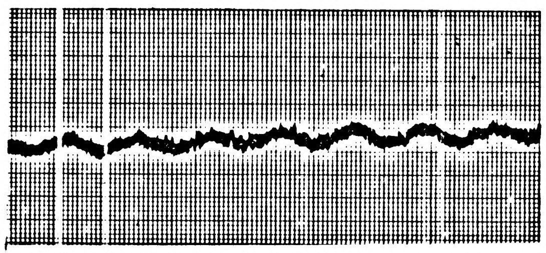
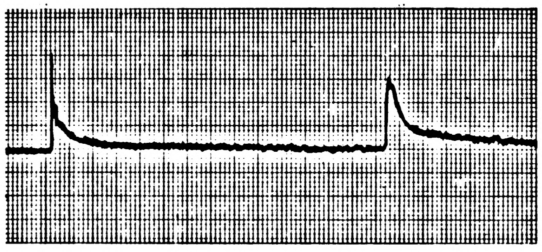

2b

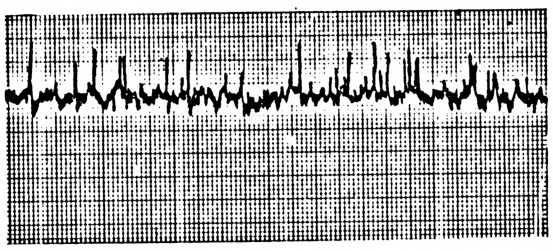
Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

Fig. 2c Provisionally accepted power trace due to oil jog.

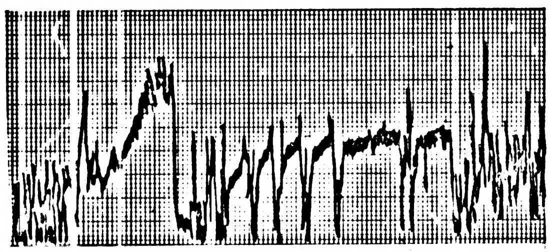

3a

Probable Cause

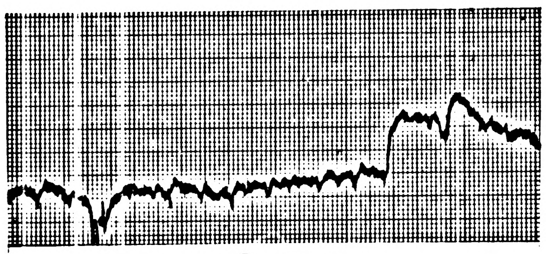
Excessive Oil Intermittant Squeal	Instantaneous power increase caused by the retainer superimposed on a rough and irregular power trace.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

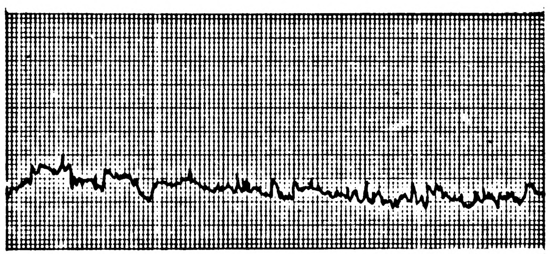
Probable Cause	
Loose Wire Retainer Squeal Low Preload Varnish Debris	Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.


3c

Probable Cause	
Varnish Low Preload One Unstable Ball Group Loose Wires	Similar to 3c

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1. 3 sec ± 15%

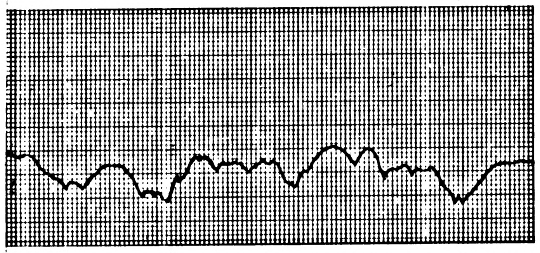
Fig. 3 (Cont.) Non-Acceptable Power Traces



3d

Probable Cause

Varnish Debris	This is typical of a varnish or debris induced power variation.



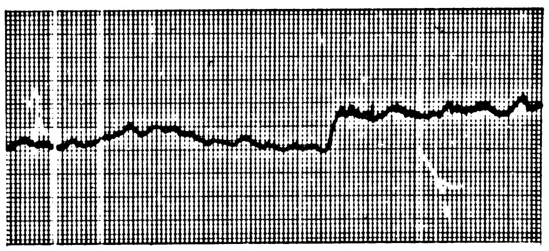
3e

Probable Cause

Varnish Debris	A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

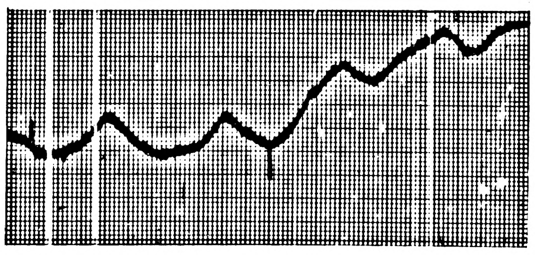
Fig. 3 (Cont.) Non-Acceptable Power Traces.



3f

Probable Cause

Slight Varnish	Early indication of a varnish build up on one or both bearings.



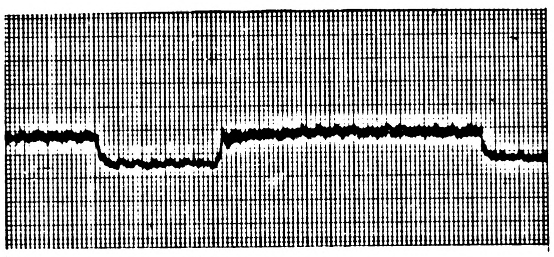
3g

Probable Cause

Varnish	This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

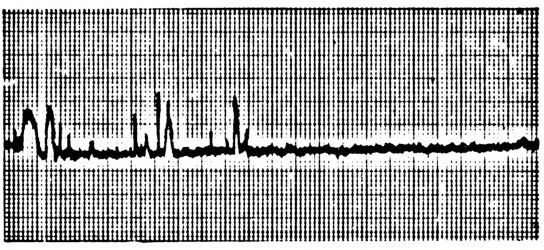
Fig. 3 (Cont.) Non-Acceptable Power Traces.



3h

Probable Cause

One Ball Group Changing Angular Velocity	Indicative of the wheel preload being too light ot control the angular velocity of the ball group in one bearing.



3i

Probable Cause

Equipment	The power variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Chart Speed	1 mm/min
Recorder Calibration	2 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

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TDRR 14046 NOV 4 1964

PREPARED BY: Hubert Vernon
DATE: February 26, 1964

MC 25-864

SHEET 1
OF 1

MAGNETIC SUSPENSION PHASING

1. Connect the gyro as shown in Figure #1 and set all eight working capacitors to the Nominal Value (0.0550 mfd.).

2. Check the following parameters:
   (a) Unit temperature------------------135 ± 2°F.
   (b) Wheel excitation------------------28 Volts
   (c) Suspension Supply Voltage--------- 4 Volts
   (d) S. G. Primary excitation----------None
   (e) Radial Signals--------------------- Normal

3. The suspension currents should be equal within 5%. A larger deviation in current indicates axial float displacement. Center the float before proceeding.
   Note: If the currents are grossly unbalanced (10 ma. or more) the axial centering can be accelerated by disabling the suspension with the lower current.

4. (a) Adjust the S. G. working capacitors in equal increments until the suspension current lags its voltage (measured from low side of swamping resistor to ground) by 45 ± 3°.
   (b) Repeat (a) above for the T. G. suspension.

5. Ensure that the suspension currents are still equal within 5%. If not, recenter the float and adjust the working capacitors as required to maintain the 45 ± 3° phasing.

6. Measure and record the average (Bridge) value of the eight capacitors from step (5).

7. Set all eight working capacitors equal to this average value within ± 1/2%.

APOLLO II IRIG Specification
MC 25-884
Release Date ____________
Release Revision ___—___
Class ___A___ Release
TDRR ___35599___

NYLASINT RETAINER PROCESSING SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 Feb 68	—	35599	INITIAL RELEASE		

This MC specification consists of page 1 to____and 1 to__3__inclusive.

TP#11938

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (Material per Dwg C-2021819) with V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg C-2021816. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 4-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 25-50 microns.

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness ' brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 20X magnification. Repeat steps a, b, or c, if necessary.

---

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150°-160°F and 25-50 microns.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0± .5 grams/minute at a line pressure of 80 psi minimum. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time (Approx.)
Ball Pockets	2 min each pocket
Outer Diameter	2 min total
Edges	2 min each edge
Inner Diameter	20 sec total

Note: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period).

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° - 150° and 25-50 microns.

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes min.

c. Finally inspect retainer for absence of burrs, contamination, and damage under 20X magnification.

---

d. Holes from pull-out of solid nylon inclusions will be premitted on the ID surface and side edges, only, of retainer. Size of holes shall be .003" deep maximum by .003" long maximum.

8. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

c. The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

APOLLO II IRIG Specification
MC 25-885
Release Date ____
Release Revision —
Class A Release
TDRR 35599

NYLASINT RETAINER MACHINING PROCEDURE

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE	R Booth	

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

TP#11938

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CAMBRIDGE, MASS.

PREPARED BY: A. Henry /V. DeMarco
DATE: October , 0, 1967
MC-25-885
SHEET 1 OF 2

NYLASINT RETAINER MACHINING PROCEDURE

1.0 Scope

1.1 This document outlines the equipment, techniques, and procedures followed by MIT to machine retainers from nylasint slugs.

2.0 Equipment Used

2.1 Precision lathe with mounting turret inclusive of:
- 2.1.1 Turning tool
- 2.1.2 Boring tool
- 2.1.3 Parting tool
- 2.1.4 Radiusing Tool

2.2 Pressure air supply and hose

2.3 .199 drill

2.4 Delrin go-no-go gage for retainer I.D.

2.5 Delrin split arbor

2.6 Retainer holding fixture (for drilling holes) inclusive of:
- 2.6.1 Brass mount
- 2.6.2 Locking thumb screw
- 2.6.3 Delrin outer
- 2.6.4 Delrin inner ring
- 2.6.5 Delrin go-no-go gage for delrin rings

2.7 Vertical milling machine inclusive of an indexing head.

2.8 Carbide drills: .0650 to .0670 in .0005 increments.

2.9 Go-no-go pins for hole sizing

3.0 Machining Procedure

3.1 Lathe Operations

3.1.1 Collet nylasint slug (2021819) approximately 1/16 to 3/32 on lathe.

Note: Lathe speed for all operations equal 1,000 rpm.

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PREPARED BY: A. Henry /V. DeMarco
DATE: October 10, 1967
MC-25-885
SHEET 2 OF 2

3.1.2 Remove approx. .005-.010 from end of slug.

3.1.3 Rough machine O.D. to approx. .850 providing sufficient length to cut two retainers.

3.1.4 Center drill nylasint with .199 drill.

3.1.5 Finish O.D. to .289 /.287.

3.1.6 Finish bore I.D. to .214 /.218.

3.1.7 Check I.D. dimension with delrin go-no-go gage.

3.1.8 Check O.D. dimension with micrometers.

3.1.9 Cut radius on outer edge while applying air pressure.

3.1.10 Part retainers to .156 /.160 .

3.1.11 Insert retainers on split arbor, and machine radius on all edges while applying air pressure. The width dimension is final machined at this operation.

Note: MIT holds width dimension within .001 so that one edge can be used to locate centerline of holes.

3.2 Vertical Mill Operations

3.2.1 Insert retainers in holding fixture. Engage thumb screw against retainer only finger tight.

3.2.2 Mount and align holding fixture in indexing jig.

3.2.3 Drill holes in retainers at 3600 rpm. spindle speed with drill selected from range specified in para. 2.8.

Note: The drill shall be directed through the nylasint wall in small incremental steps to achieve a smooth surface on the hole I.D. Air pressure shall be applied when drilling.

3.2.4 Check hole dimensions with go-no-go gages.

4.0 General Notes

4.1 Caution should be exercised to minimize moisture absorption during machining as moisture content will affect geometry.

APOLLO II IRIG Specification
MC 25-886
Release Date ______
Release Revision --
Class A Release
TDRR 35599

APOLLO II WHEEL ASSEMBLY DATA

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 Feb 68	—	35599	INITIAL RELEASE	RBooth	

This MC specification consists of page i to ___ and 1 to 2 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
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CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: October 10, 1967

Apollo II Wheel Assy Data
MC 25-886
SHEET 1 OF 2

Wheel Number ______ Operating Temperature ______
Preload Spacer Thickness ______ Assembled by ______
Contact Angle End #1 ______ Date ______
End #2 ______
Bearing Room Temp. ______ Lapping Room Temp. ______

Interference Fits	Design Value at Room Temp.	Measured Value at Room Temp.
Insert on Wheel Hub	.0002 - .0006	
Hysteresis Ring on Insert	.0002 - .0006	
Inertia Rims on Insert	.0002 - .0006	

Weights of Components	Design Value at Room Temp.	Measured Value at Room Temp.
Wheel Hub	19.571	
Hysteresis Ring	4.444	
Inertia Rims (2)	55.620	
Spacer	0.724	
Cap (2)	0.922	
Shaft & Brg. Assy.	5.650	
#0-80 Screws	0.562	
Total Wheel Weight	87.600 ± .250	

Bearing O.D. (mean Dia. At Bearing Rm. Temp.) End I ______ End II ______

Increase in bearing O.D. at Operating Temp. from Fig. I (Correction "A") + ______ + ______

Bearing O.D. at Operating Temp. & Required size of bore at operating temp. ______ ______

Decrease in bore from Operating Temp. to lapping room temp. from Fig. 1 (Correction "B") - ______ + ______

Required bore size at lapping room temp. ______ ______

Actual finished bore size at above temp. ______

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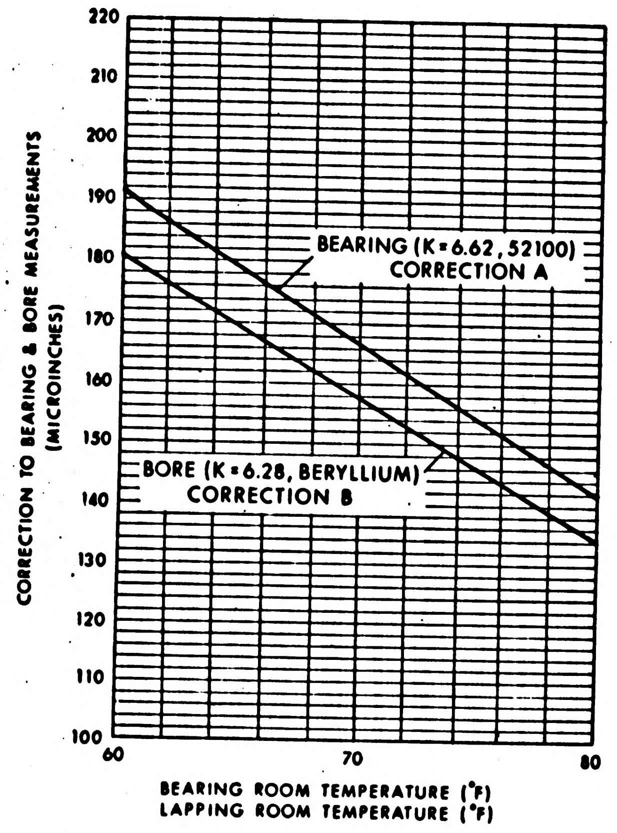
DATE: October 10, 1967

Apollo II Wheel Assy. Data
MC 25-886
SHEET 2 OF 2



NOTES:

1. This graph applies to $\frac{3}{8}$ nominal O.D. bearing only.
2. K = Thermal coefficient of linear expansion in 10^{-6} "/"/°F
3. Operating temperature = 137 °F

APOLLO II IRIG Specification
MC 25-887
Release Date ________
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Class A Release
TDRR 35599

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 Feb 68	—	35599	Initial Release		

TP#11938

This MC specification consists of page 1 to____and 1 to 4 inclusive.

BEARING INSPECTION AND ACCEPTANCE SPECIFICATION

1. ENVIRONMENTAL CONDITIONS 45% Humidity 75°F ± 2°F
2. CRITICAL AREAS--The critical areas shall be as shown in Figure 1.
3. ACCEPTANCE CRITERIA--The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination of 30 power magnification.

The critical areas of the races shall show a characteristic ground and polished, honed or lapped finish.

The critical areas shall be free from tool marks, chatter waves, grinding scratches, rust, seams, inclusion, and pits, except as modified by the following:

a) A pit shall be any imperfection of a size such that the dimension across its major axis is greater than 0.0005 inch. Any imperfections less than this are acceptable.
b) No pit shall exceed 0.0012 inch across its major axis and no two pits shall be closer than 0.012 inch.
c) The maximum number of pits in the critical areas shall not exceed four per part.
d) Scratches, comet tails, grind tears, and cuts running circumferentially in the critical ball track area shall not exceed 0.0012 inch in width, and no raised metal is acceptable.

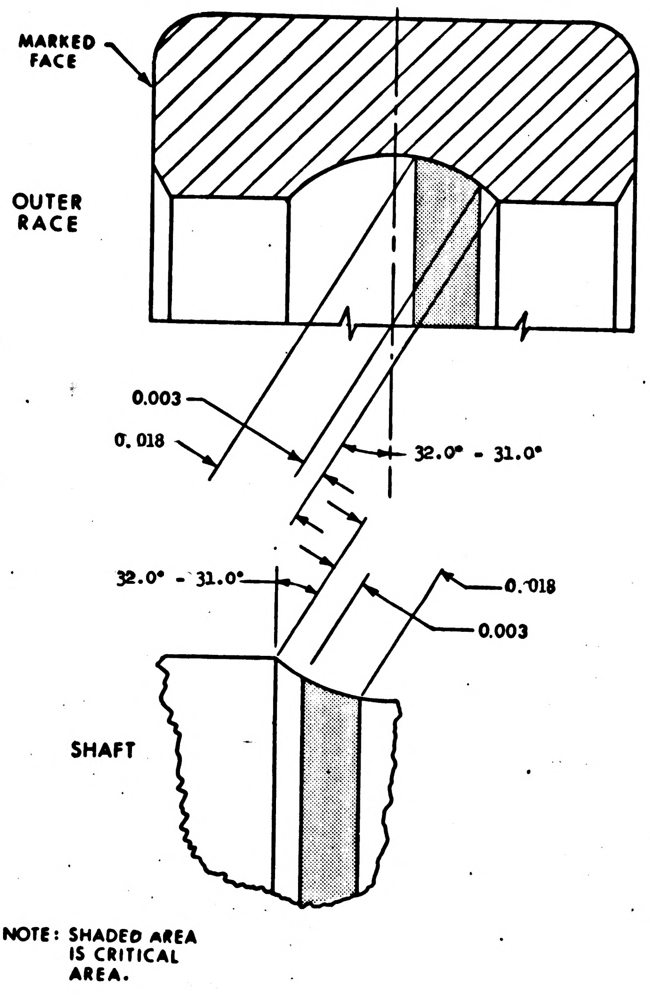

Fig. 1 Critical ball race areas.

---

e) Scratches across the critical area shall not exceed 0.0005 inch in width.
f) No rust shall be present.

4. BALLS

a) The ball luster shall be very bright and the surface matte must be very fine. The following criteria shall determine the acceptability of the balls after microscopic examination under 10 power magnification.

(1) Defects---There shall be no noticeable defects as follows:
(a) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets in excess of .0012 inch width.
(b) Stains and rust - none
(c) Burrs - none
(d) Scratches - 0.0005 inch wide, showing no raised metal
(e) Flats - .0002 inch maximum width.

5. Non critical Areas. - Non critical areas shall be all those not covered by the requirements of Paragraphs 2 and 3.

a) Acceptance Criteria. - The following criteria shall determine the acceptability of the outer race and shaft after microscopic examination under 10 power magnification.

Defect	Ground Surfaces	Chamfers, Undercuts, Threads and Machined Bores
(1) Nicks, dents, pits, inclusions, fragmentation denting, brinell marks, tears, cuts, or comets	.0003 inch	None which affect dimensional tolerances.

(2)	Stains, rust	None	No rust, stains acceptable.
(3)	Burrs,	None	None which affect dimensional tolerances.
(4)	Scratches	None which affect dimensional tolerances	None which affect dimensional tolerances
(5)	Flats	None which affect dimensional tolerances	None which affect dimensional tolerances

6. Contact angle determination - All necessary components of the contact angle shall be measured in accordance with the following formula to determine the contact angle:

$$\text{Cosine } \beta_o = \frac{E}{d}\left[1 - \left(\frac{2 \cdot N_E}{N_i}\right)\right]$$

where E = pitch diameter of 0.249450(print nominal value)

d = average ball diameter of row (vendor supplied information)

N_E = number of revolutions of the retainer

N_i = Number of revolutions of the inner race

β_o = contact angle

APOLLO II IRIG Specification
MC 25-878
Release Date ________
Release Revision —
Class A Release
TDRR 35599

CLEANING SPECIFICATION, BEARINGS, 52100 STEEL,

APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval	
				MIT	NASA
13 FEB 68	—	35599	INITIAL RELEASE		

TP#11938

This MC specification consists of page 1
to____and 1 to 1 inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 29 July, 1967
MC 25-878
SHEET 1
OF 1

CLEANING SPECIFICATION, BEARING, 52100 STEEL,

APOLLO II IRIG

1.0 SCOPE

1.1 This specification covers the cleaning procedure for all outer races, balls, and shafts before assembly as a unit bearing.

2.0 CLEANING PROCEDURE

2.1 Clean parts with cotton and Engsol.

2.2 Ultrasonically clean the metal parts in toluene, freon and methanol for five minutes in each solution. Vacuum dry after each solution. Vacuum fixture shall be of sufficient capacity so as to instantaneously remove solvent thus minimizing formation of residual films.

2.3 Dip each part into a solution of 50 precent acetone and 50 percent methanol and then vacuum dry.

2.4 Visually inspect all parts under a microscope at 30X.

APOLLO II IRIG Specification
MC 25-889
Release Date ____________
Release Revision —
Class A Release
TDRR 35599

Equipment Specification for Milliwattmeter Testing of Apollo II Wheels

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

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CAMBRIDGE, MASS.
PREPARED BY: E. Hall, B. Rockower
DATE: October 4, 1967
MC-25-889
SHEET 1 OF 2

Equipment Specification for Milliwattmeter Testing of Apollo II Wheels

1.0 Equipment Specification

1.1 Power Supply
Voltage 28V ± 2% phase
Stability 0.1%

1.2 Milliwatt (Power Monitor Panel) (MIT DWG No. C-135341)
Calibration mark 25 milliwatts

1.3 Recorder
Sanborn Recorder with Servo Monitor Preamplifier Model 150-1200 or equivalent
Chart Speed 1 mm/ minute
Time Constant (Modified) 1.3 ± 15% Sec.
Sensitivity 2.0 MW/MM ± 10%

1.4 Temperature Controller
Type: Optional
Controller to maintain gyro at 135 ± 1°F measured at the gyro thermistors

1.5 Connections to the Power Monitor
To the AMPL Post connect the Reference Signal Lead of the Servo Monitor Preamplifier and either A Hi or B Hi Lead from the wheel supply.
To the WHL Post connect the A Hi or B Hi Float Load, Corresponding to the Phase Connected to the AMPL post.
To the BRDG OUPT post connect the Error Signal Lead of the Servo Monitor Preamplifier.

2.0 Calibration Procedure

Set up the recorder per manufacturer's instruction manual. Install 3μ fd capacitor between preamplifier output and driver amplifier input. Allow the gyro to reach operating temperature. Turn on the wheel supply and set the Wheel Supply LEVEL Control for 28 volts. Ascertain that the wheel reaches synchronous speed. (When the wheel reaches synchronous speed the wheel current will drop).

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PREPARED BY: E. Hall, B. Rockower
DATE: October 4, 1967
MC 25-889
SHEET 2 OF 2

Patch the VTVM Lead into the BRDG OUPT Post of the Power Monitor Panel. Adjust R 1 and R 2 of the Power Monitor Panel to obtain the lowest null as indicated on the VTVM. Remove the VTVM Lead from the BRDG OUPT Jack. Depress the CAL switch of the Power Monitor Panel. Set the recorder sensitivity for a deflection of the recorder per 12-1/2 mm on the chart paper when the CAL switch is depressed.

APOLLO II IRIG Specification
MC 25-879
Release Date ________
Release Revision —
Class A Release
TDRR 35599

TCP COATING OF BALL BEARING 52100 STEEL,

APOLLO II IRIG

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
13 FEB 68	—	35599	INITIAL RELEASE		

TP#11938

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 29 July 1967
MC 25-879
SHEET 1
OF 2

TCP COATING OF BALL BEARING 52100 STEEL,

APOLLO II IRIG

1.0 SCOPE

1.1 This specification covers the cleaning and soaking procedures that shall be followed in preparing balls and races of 52100 steel.

2.0 INITIAL CLEANING PROCEDURE

2.1 The following cleaning procedure shall be used before TCP soaking of balls and races of bearing.

2.1.1 Clean with cotton and Engsol.

2.1.2 Ultrasonically clean the metal parts in toluene, freon, and methanol for five minutes in each solution. Vacuum dry after each solution. Vacuum fixture shall be of sufficient capacity so as to instantaneously remove solvent thus minimizing possible formation of residual films.

2.1.3 Dip each part into a solution of 50 percent acetone and 50 percent methanol and then vacuum dry.

2.1.4 Immediately place in acetone in Soxhlett extractor. Acetone extract for 16 hours minimum.

2.1.5 Vacuum dry and immediately place in TCP at room temperature.

3.0 TCP TREATMENT

3.1 Place components in a suitable jar containing Tricresyl-Phosphate (TCP). All parts shall be completely submerged.

3.2 Cover jar and place in a preheated vented oven at a temperature of 225°±5°F.

3.3 Store parts in the TCP bath for 15 days minimum at above temperature.

3.4 During high temperature storage period, all parts should be moved daily.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 29 July 1967
MC 25-879
SHEET 2
OF 2

4.0 FINAL CLEANING PROCEDURE

4.1 Cleaning procedure outlined in paragraphs 2.1.2 and 2.1.3 shall be followed.

4.2 Visually inspect all parts under a microscope at 30X.

4.3 If parts are not assembled as a unit bearing, dip parts in Teresso V-79 and seal in package.

APOLLO II IRIG Specification
MC 25-921 REV A
Release Date 21 July 69
Release Revision ---
Class A Release
TDRR 37699

Title: Nylasint Retainer Processing Specification

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	NASA
1/23/70	A	38011	2	EA	MDH

TP#11938

This MC specification consists of page i to ___ and 1 to 4 inclusive.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 24 June 1969
MC 25-921
SHEET 1 OF 4

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (per SCD 2021819) with V-78 or V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg 2021829. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in.hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 30X magnification. Repeat steps a, b, or c, if necessary.

---

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150° -160°F and 29 1/2 in. hg. minimum.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0 ± .5 grams/minute at a line pressure of 80 psi minimum. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure (Ref)
Ball Pockets	30 sec each pocket
Outer Diameter	10 sec total
Edges	10 sec each edge
Inner Diameter	30 sec total

NOTE: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period)

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° - 150°F and 25-50 microns.

f. Equipment
S. S. White Industrial Abrasive unit
model G
201 East 42nd Street
New York, N. Y. 10017 or equivalent
NOTE: Handpiece 351-1793y (approx .040 dia) without nozzle attachment shall be used as a nozzle

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

---

c. Finally inspect retainer for absence of burrs, contamination, and damage under 30X magnification.

d. Holes from pull out of solid nylon inclusions will be permitted on the O.D. surfaces and side edges of the retainer processed to dwg. 2021829. Pull out at the edges of the ball pocket surfaces which intersect the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. and O.D. surface and the ball pocket surface. The depth of blend may not exceed 0.010 inches into the ball pocket or the O.D. or I.D. surface. (See fig. 1.)

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material. No inclusions will be permitted where ball makes contact in pocket. NOTE: Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown and black) inclusions are acceptable only if they are imbedded below the surface of the retainer surface.

8. Oil Absorption Test

a. Check retainers for oil absorption test per MC 25-713.

b. After oil absorption test reclean the retainers per paragraphs 6c, 6d, and 6e of this specification.

9. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

c. The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.

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CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 24 June 1969
MC 25-921
SHEET 4
OF 4

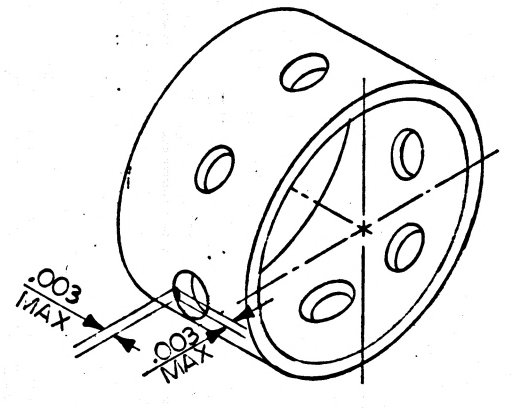
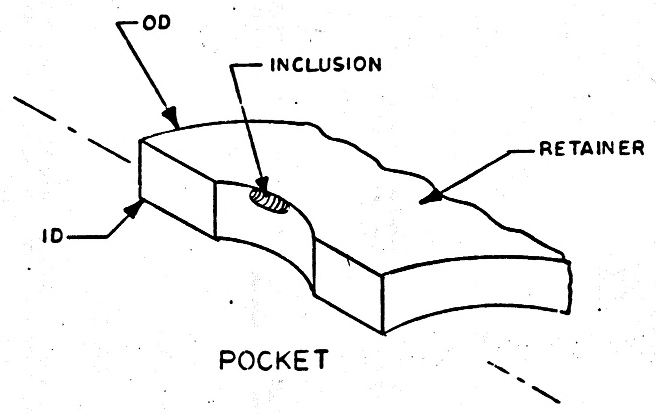

.003
MAX
.003
MAX

FIG 1
BALL POCKET BLEND


OD
INCLUSION
RETAINER
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POCKET

APOLLO II IRIG Specification
MC 25-922
Release Date 28 JAN 70
Release Revision A (CCS 934)
Class A Release
TDRR 38019

Title: Apollo II IRIG Visual/Mechanical Inspection for Shrouded Unit Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval CCB	Approval NASA
1/28/70	A	38019	INITIAL RELEASE	GA	—

TP#11938

This MC specification consists of page 1 to ____ and 1 to 7 inclusive.

Apollo II IRIG Visual/Mechanical Inspection for Shrouded Unit Assembly

1. GENERAL

The criteria for acceptance of the shrouded unit assembly (ND 2021602) from a visual and metrological standpoint is detailed in this specification.

2. MECHANICAL INSPECTION

The dimensional inspection of the instrument will be conducted per Figure 1.

3. VISUAL INSPECTION

3.1 Visually inspect the entire assembly to be free from burrs, foreign matter, corrosion and damage. Minor depressions or scratches which do not affect the outline dimensions are permissible; however, such conditions are to be noted as "Observations" and listed on Form 1 (Figure 2).

3.2 Using 10X magnification, inspect the following (the solder acceptance criteria is per Para. 3.3):

3.2.1 Solder bands securing the SG (ND 2021614) and TG (ND 2021802) end covers to the main cover (ND 2021612).

3.2.2 Solder bands securing the two main cover inserts (ND 2021617) to the main cover.

3.2.3 Solder around the sixteen terminals (ND 2021508) and degassing seal (ND 2021616) on each end cover.

3.2.4 The glass seals of the sixteen terminals on each end cover. The glass shall have no cracks.

3.3 Solder Acceptance Criteria

3.3.1 All soldering will display good wetting and adherence to metal parts. Fractured solder joints are not allowed.

3.3.2 The solder joints around the sixteen terminals and degassing seal of each end cover shall be free of voids and pinholes. See Figure 3.

3.3.3 Voids/pinholes adjacent to the terminals and degassing seals shall not be cause for rejection. See Figure 3. (Voids/pinholes not allowed in the fillet area forming the hermetic seal.)

3.3.4 Depressions, low spots, or slight pullout around the main cover/end cover seals and insert/main cover seals are permissible if a continuous flow of solder is evident at the interface of the solder and the piece parts. See Figure 4.

NOTE: Slight pullout is defined as nicks caused by tooling at time of clean up. The pullout shall not extend through the solder joint.

3.4 Visual Characteristics of 416 CRES (Inclusions, etc.)

3.4.1 General

Sulfur and/or Selenium are added to stainless steels to improve machinability so that the chips formed are short and the speed of machining is much higher. In Class 416 corrosion resistant steel, sulfur is generally added in the range 0.20 to 0.30 percent.

The additions result in the formation of stringers which are randomly dispersed lengthwise in the direction of rolling. In general, these stringers are short, very small and uniformly dispersed throughout the matrix. When the sulfur additions are in this form, they can only be observed under high magnification.

Occasionally segregation occurs and gross aggregates can form. Once again, in most cases, these aggregates are present in discrete quantities, and it is very rare that they would be present in long elongated forms. Such stringers, whether as gross aggregates or in a form of fine threads, are always in the direction of rolling and will show up as a mark at right angles to the direction of machining.

3.4.2 Inclusion Segregations

If Class 416 corrosion resistant steel is being used as the SG end cover material, there is always the possibility that gross sulfide inclusions may be present on the cover surface. It may be possible to observe these linear indications under magnification as low as 10X. These heavy inclusions will generally not exceed .001" in depth. Inclusions are not considered cause for rejection of the shrouded unit assembly.

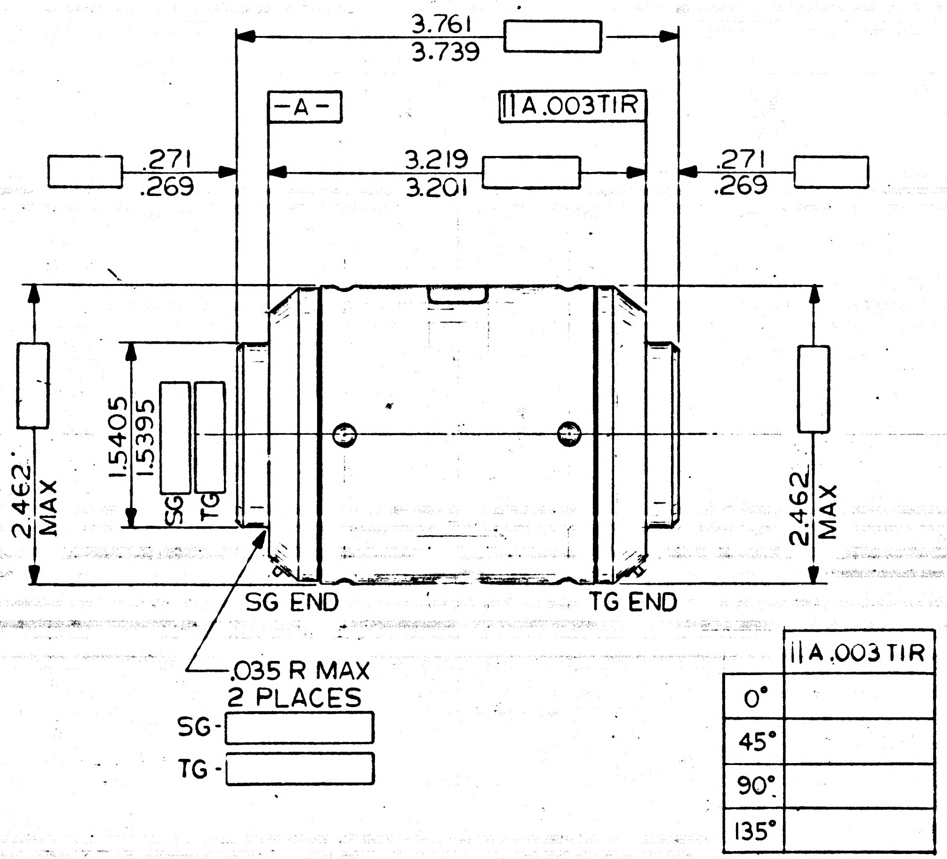
3.4.3 Identification Procedure

To differentiate exposed surface inclusion stringers from scratches or cracks, it will be noted that inclusions will have the following visual characteristics:

a) Inclusions have very shallow depth, whereas cracks are generally deeper than .001".

b) Inclusion stringers are linear and generally parallel to the axis of the cover. Inclusions often are seen as discontinuous, short, linear indications. Cracks and scratches may have any orientation.

c) Inclusion stringers will not reflect light as would be the case with surface scratches when examined under a microscope by varying the position of the light source.


3.761
3.739
-A-
∥A .003 TIR
.271
.269
3.219
3.201
.271
.269
2.462
MAX
1.5405
1.5395
SG
TG
2.462
MAX
SG END
TG END
.035 R MAX
2 PLACES
SG-
TG-

	∥A .003 TIR
0°	
45°	
90°	
135°	

FIGURE 1

MC 25-922
Rev A

Sheet 4
Of 7

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS

PREPARED BY P. Kerrigan ;C. Cormier
DATE December 1969

MC 25-922
Rev A

SHEET 5
OF 7

OBSERVATION SHEET
APOLLO IRIG SHROUDED UNIT ASSEMBLY

UNIT SERIAL NUMBER ____________ DATE ____________

INSP ____________

Item No.	Visual Observations

Form 1. Figure 2.

IL 27

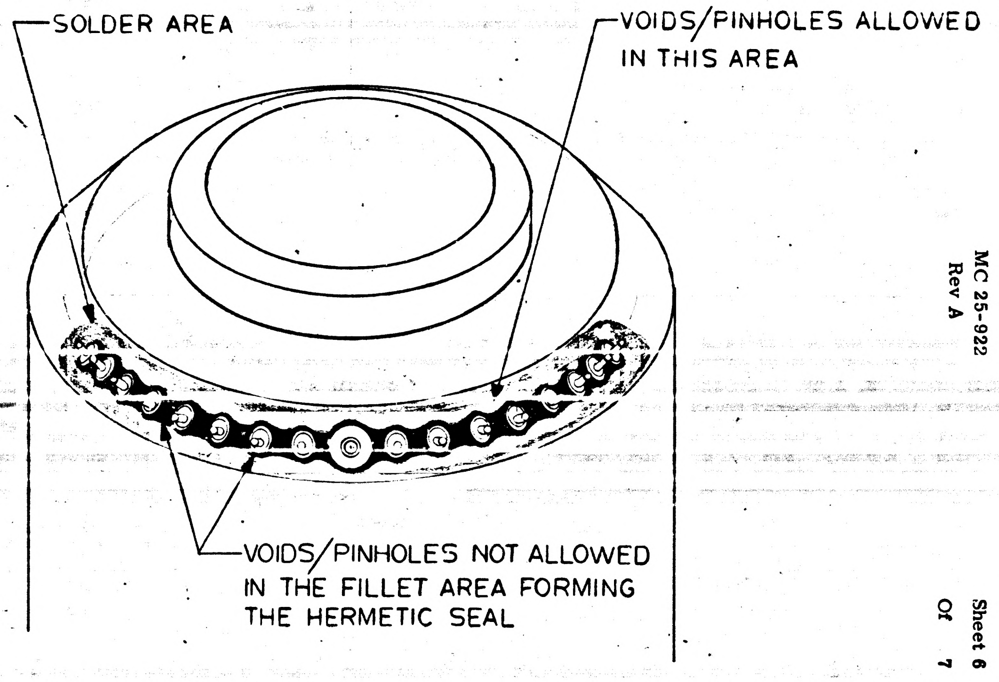

SOLDER AREA
VOIDS/PINHOLES ALLOWED IN THIS AREA
VOIDS/PINHOLES NOT ALLOWED IN THE FILLET AREA FORMING THE HERMETIC SEAL

FIGURE 3

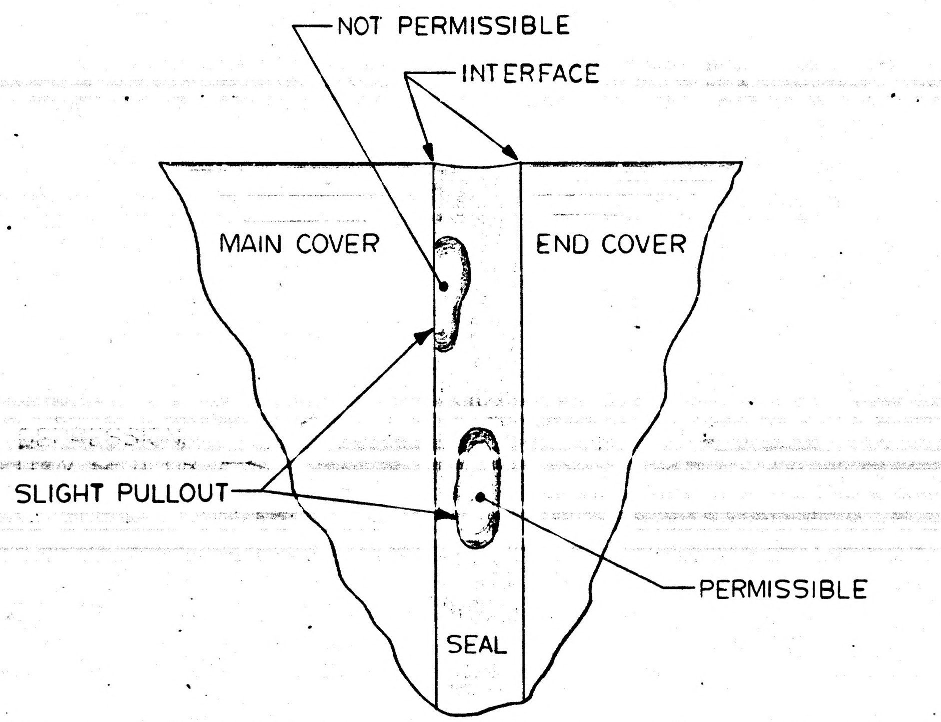

NOT PERMISSIBLE
INTERFACE
MAIN COVER
END COVER
SLIGHT PULLOUT
PERMISSIBLE
SEAL

FIGURE 4

APOLLO II IRIG Specification
MC 25-919
Release Date 21 July 69
Release Revision —
Class A Release
TDRR 37699

Title: Evaluation of Apollo II Wheel in Dynamometer

Date	Revision Letter	TDRR No.	Pages Revised	Approval AC	Approval NASA
11/24/69	A	37925	3	MGM EA	MDH

This MC specification consists of page i to ___ and 1 to 17 inclusive.

TP#11938

Evaluation of Apollo II Wheel in Dynamometer

1.0 Temperature Cycle Test

Before evaluating the wheel over the 200 hour qualification period, the wheel shall be run at synchronous speed for the periods of time and at the operating temperatures specified below.

Period of Time	Operating Temperature
24 ± 12 hours	137 °F
6 ± 1/2 hours	125 °F
24 ± 1 hours	160 °F

Dynamometer performance may be monitored during this period but is not a specification requirement. After running wheel at above temperatures, remove wheel from dynamometer and visually inspect both bearings under 30X microscope. Examine both bearings for any evidence of incipient varnish build up on either retainer ball pockets or raceways. Also examine for any discoloration of raceways or balls. Any evidence of varnish or discoloration is cause for rejection of the wheel assembly. Also check for presence of oil meniscus between balls and inner race. If meniscus is not present, use 0.002 diameter platinum wire to add $0.010^{+.000}_{-.002}$ diameter drop of oil (per SCD 2021827) to ball or inner race.

2.0 General Requirements

The wheel evaluation test will be made on wheels which pass the temperature cycle test described above. Wheel evaluation will be made over a 200 hour qualification period using rundown time measurement, breakaway voltage measurement, minimum voltage to synchronous speed and torque monitoring as the critical parameters. During qualification, wheel shall be operated in ambient of one half atmosphere of helium. Alternate: 5.0 psig helium. Prior to setting ambient, dynamometer fixtures shall be evacuated to 20 in. mercury vacuum and back filled with helium to one atmosphere. Repeat evacuation and backfill five times minimum.

2.1 Rundown Time Measurements

The wheel qualification rundown time measurements shall be taken twice in each 24 hour period with a minimum of four (4) hours between rundowns. After the first 50 hours of wheel qualification a minimum of one rundown time measurement may be taken in each 24 hour period except on weekends or holidays. The total number of rundown time measurements shall not be less than 12. To measure rundown time, switch off wheel momentarily

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to dissipate any overexcitation and proceed per MC 25-834. Wheel operating temperature and other rundown data shall be recorded on MC-811.

2.2 Breakaway Voltage Measurements

The wheel qualification breakaway voltage measurements shall be made per MC 25-873 once every 24 hours during the qualification period. Record data on MC-811.

2.3 Minimum Voltage to Reach Synchronous Speed

The wheel must be capable of reaching synchronous speed at 26.6 volts. Minimum voltage measurements shall be made once every 24 hours during the qualification period. Record data on MC-811.

2.4 Torque Monitoring

The wheel qualification torque monitoring recording shall be performed during the entire 200 hour qualification period for acceptable wheels. Refer to MC 25-888 for the wheel qualification equipment specification. The recording shall be continuous except for interruptions due to scheduled rundown time measurements and interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

3.0 Disposition Points

There are two formal points in time for making wheel dispositions, namely the fiftieth and the two hundredth hours of wheel operations. Fig. 1 serves to clarify the use of these formal disposition points and indicates a wheel qualification program yield history. Dispositions at points other than the 50th and 200th hour are allowed but not required.

3.1 Fifty Hour Disposition

Within 24 hours after the completion of the first 50 hours of wheel qualification a disposition shall be made using the following criteria.

3.1.1 Rundown Time Repeatability

If the maximum difference between the four (4) rundown time measurements is greater than 10 seconds, two more measurements shall be taken at 15 min. minimum intervals to determine if rundown time is bad or if level is actually changing. Final disposition shall be made after 200 hours using all rundown time measurements (See para. 2.1).

3.1.2 Torque Monitoring and RDT Performance

The criteria for acceptance in the dynamometer evaluation lies in the interpretation of the recorded trace taken between each rundown time interval. In order to provide objectivity in this interpretation reference will be made to a number of characteristic forms of the dynamometer trace and specifications or limits imposed on each. The following identification pertains to dynamometer traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. The torque stability and wheel rundown requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.

To this end, acceptance of wheels with variations in torque stability and wheel rundown times are permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

3.1.2.1 Acceptable Torque Trace

The principal requirements for an acceptable wheel is performance during the monitoring period that is free of non-periodic or step torque variations greater than 75 dyne-cm. Fig. 2a, b, c represent acceptable torque traces with 2b and 2c indicating acceptable periodic variations. (The variations are due, in this case, to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 150 dyne-cm. The maximum allowable variation in trace width during the total wheel monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period compared to the level exhibited during the period between the fifth hour of running and the first wheel rundown. The allowable increase is as indicated below.

5th Hour to 1st RDT Average Dyna. Torque	Allowable Maximum Trace Width at Any Time Average Dyna. Torque
25	75
50	100
75	100
100	125
125-150	150

3.1.2.2 Provisionally Acceptable Torque Trace

There are two catego-ies of torque variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

3.1.2.2.1 Torque Level Disturbance

Fig. 3a is typical of torque trace exhibiting a disturbance of the torque level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than once during the 50 hour qualifying period as shown in Figure 1.

3.1.2.2.2 Test Equipment Influences

Fig. 3b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory torque trace. If the period of the sirusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller than this component of the torque trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

3.1.2.3 Oil Jogs

Fig. 3c is a typical torque trace illustrating oil jogs. If the total integrated area of oil jobs within any one hour period is greater than 720 dyne-cm-minute, the wheel shall be rejected.

NOTE: The procedure for calculating the area of oil jogs is as follows:
Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area illustrated by Figure 5.

3.1.2.4 Non Acceptable Torque Trace

Any torque trace resembling Fig. 4a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are squeal (Fig. 4b), intermittent squeal (Fig. 4a), low preload (Fig. 4b, c), incipient varnish failure (Fig. 4b, c, d, e, f), debris (Fig. 4b, d, e), loose wires (Fig. b, c), one ball group unstable (Fig. c, h), equipment malfunction (Fig. 4i).

3.1.2.5 Retainer Stability Motion Study

If a wheel is rejected because of non-acceptable torque trace, retainer motion shall be observed to assist in determining reason for wheel failure. Place wheel in milliwattmeter fixture (drawing E-159826). Wheel shall be [illegible]

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operated in ambient one-half atmosphere helium or 5 psig and at operating temperature (137°F). Run wheel up to synchronous speed. Adjust binocular microscope (American Optical or equivalent) to 10 power and focus on one of the retainers of running wheel. With variable oscillator, externally trigger stroboscope with sufficient excitation to fire stroboscope and electronic counter. Set oscillator at retainer frequency (Ref. 243 Hz) and aim stroboscope at bearing as close as possible. Adjust oscillator until retainer appears to "stop" and observe stability of motion. Continue observation with retainer slowly drifting for possible signs of erratic behavior. Repeat observations with second bearing.

3.1.2.6 Other dynamometer requirements

The maximum variation in mean torque level shall not exceed 200 dyne-cm. The minimum allowable torque level shall be 800 dyne-cm (normal range 800-1800 dyne-cm, reference only)

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3.2 Two Hundred Hour Disposition

After a minimum of 200 hours of wheel qualification a disposition shall be made using the following criteria.

3.2.1 Rundown Time

3.2.1.1 The RMS of all wheel rundown times (σ_D) shall be equal to or less than 5 seconds.

3.2.1.2 The RMS of the wheel rundown time (σ_D) shall be calculated using the following

$$\sigma_D = \sqrt{\frac{(T_1 - A_D)^2 + (T_2 - A_D)^2 + \ldots\ldots (T_n - A_D)^2}{n}}$$

A_D = Average run-down time to 6000 rpm

n = Number of run-down checks (no less than 12)

$T_1 \ldots T_n$ = Run down time to 6000 rpm

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the wheel assembly.

3.2.2 Breakaway Voltage Measurement Comparison

The breakaway voltage at the beginning and end of the wheel qualification period should be examined. Although no specification requirement is imposed herein, this information should be examined along with the rundown times and torque traces. Like decreasing rundown times, a significant increase of breakaway voltage is indicative of incipient bearing failure.

3.2.3 Torque Monitoring Performance

The criteria of section 3.1.2 are to be applied to the 200 hour disposition.

3.2.4 Synchronous Voltage Measurement Comparison

Minimum voltage to reach synchronous speed at the beginning and end of the wheel qualification period should be compared. This information should be examined along with breakaway voltage measurements, rundown times and torque traces for any indication of incipient bearing failure.

3.2.5 After removing wheel from dynamometer, visually inspect both bearings under 30X microscope. Examine both bearings for any evidence of incipient varnish build up on either retainer ball pocket or raceways. Also examine for any discoloration of raceways or balls. Any evidence of varnish or discoloration is cause for rejection of the wheel assembly. Bearings shall also be inspected for presence of an oil meniscus between balls and inner race. This examination for the presence of a meniscus should be done within an hour at most from the last wheel running period. The absence of a meniscus is considered serious and either rejection of the wheel or suitable corrective action under the direction of the gyro wheel review committee shall be the indicated appropriate action. Suitable corrective action can include further oil addition and continued dynamometer running time followed by an additional visual examination.

17

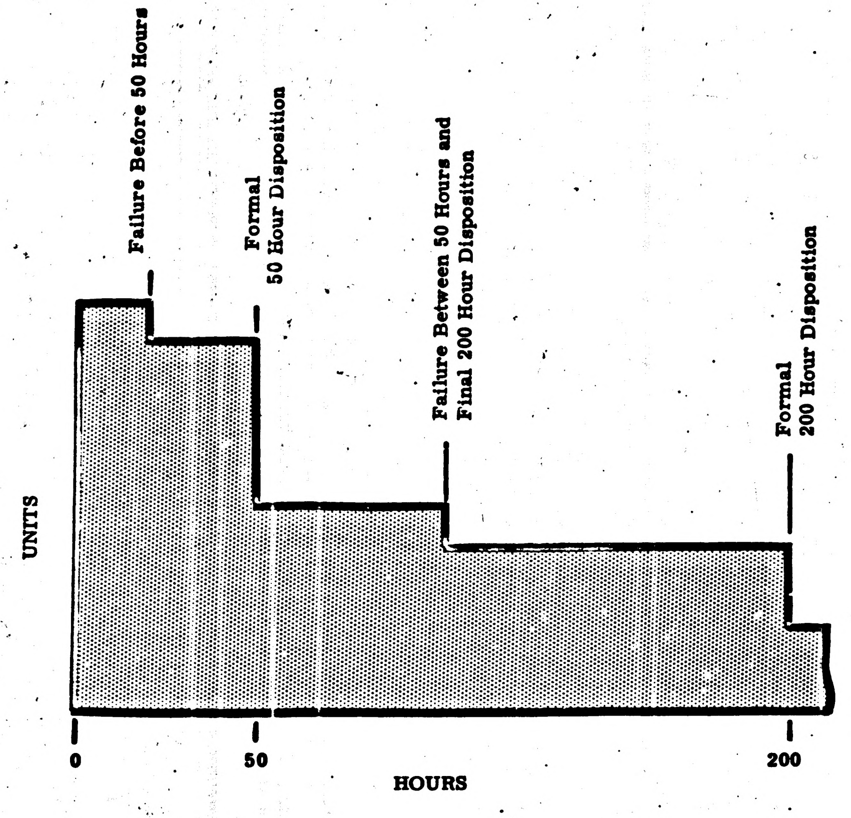


Fig. 1 Illustrative Wheel Qualification Program Yield History.

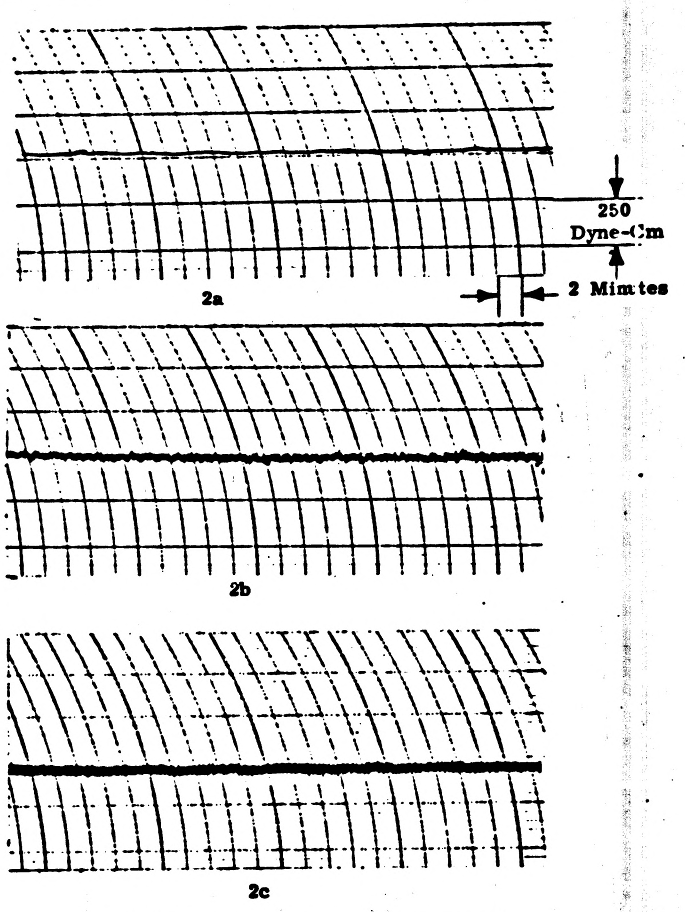


Chart Speed	6 inches/Hour
Recorder Calibration	25 D.C./mm
Recorder Time Constant	0.3 sec ± 15%

*

Fig. 2 Acceptable Torque Traces
* Chart information applicable to figures 2, 3, 4.

13

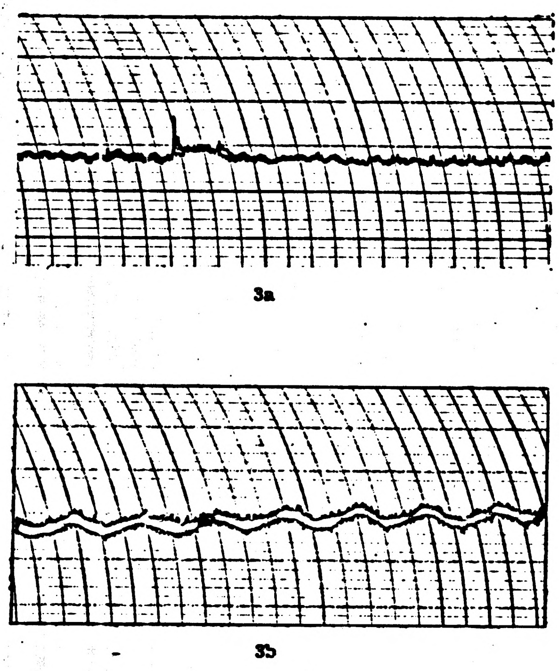
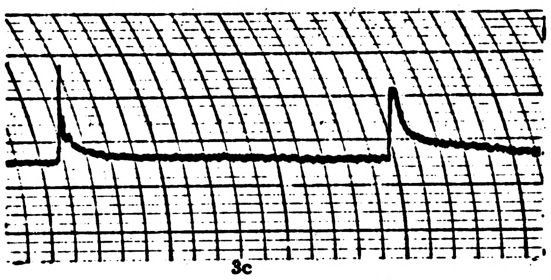


Fig. 3 Provisionally Acceptable Torque Traces

19

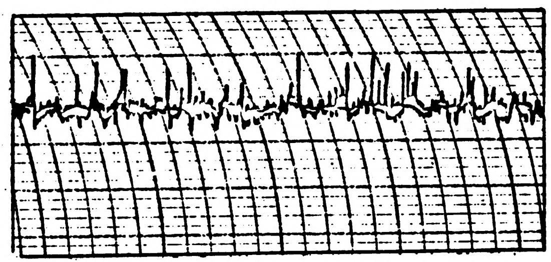


3c

Probable Cause

Oil jog

Instantaneous torque increase and gradual decay caused by an excess of lubricant being thrown into the ball track.



4a

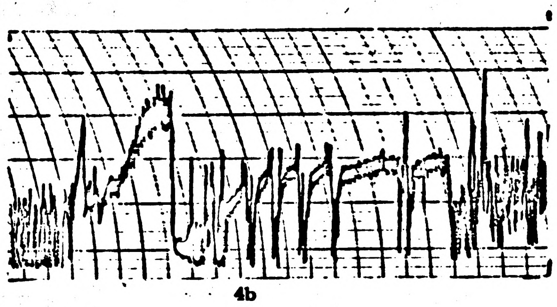
Probable Cause

Excessive Oil
Intermittent Squeal

Instantaneous torque increase caused by the retainer superimposed on a rough and irregular power trace.

Fig. 4 Non-Acceptable Torque Traces.

51

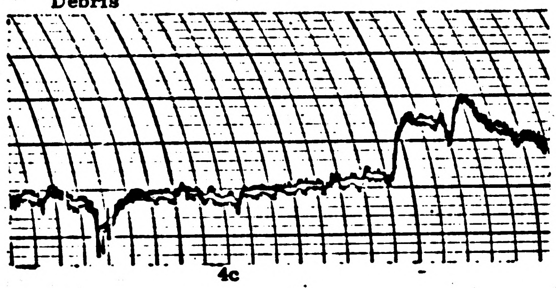


4b

Probable Cause

Loose Wire
Retainer Squeal
Low Preload
Varnish
Debris

Extremely irregular torque trace that could be attributed to any or all of the listed causes singly or in combination.



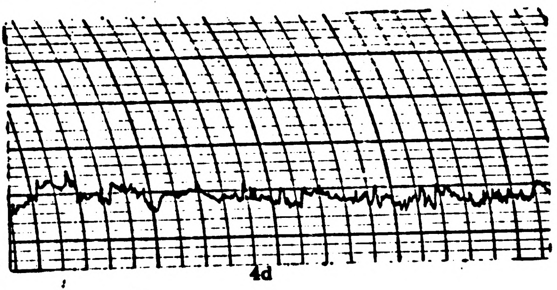
4c

Probable Cause

Varnish
Low Preload
One Unstable Ball Group
Loose Wires

Similar to 4b.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

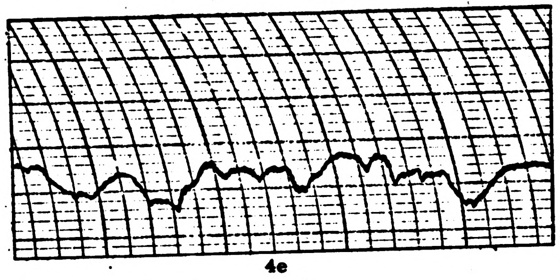


4d

Probable Cause

Varnish
Debris

This is typical of a varnish or debris induced torque variation.



4e

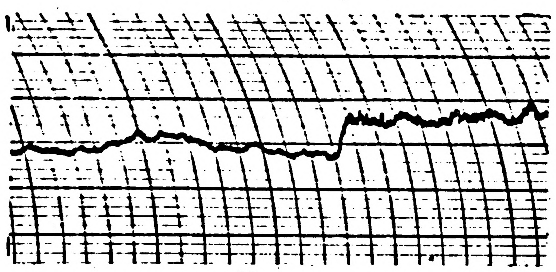
Probable Cause

Varnish
Debris

A torque variation induced by debris or varnish, not as common as 4e but a positive indicator of an incipient failure.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

53

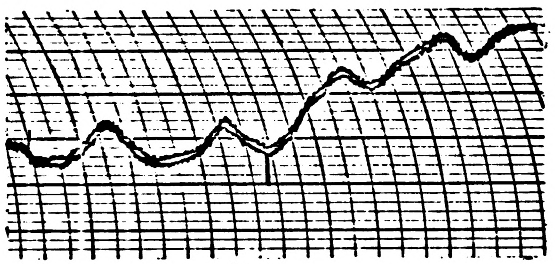


4f

Probable Cause

Slight Varnish

Early indication of a varnish build up on one or both bearings.



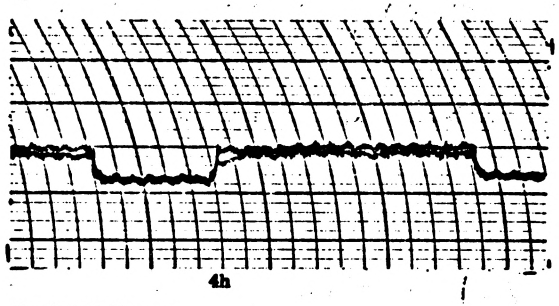
4g

Probable Cause

Varnish

This trace shows a steady increase in torque with a superimposed sinusoid attributable to a temperature control cycle.

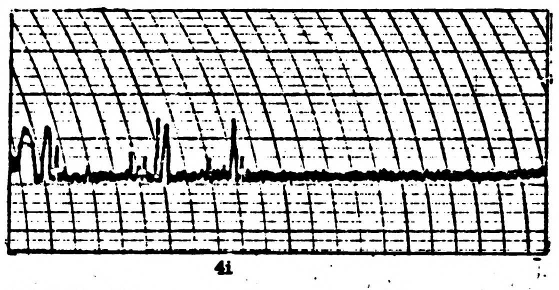
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4h

Probable Cause

One Ball Group Changing Angular Velocity	Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



4i

Probable Cause

Equipment	The torque variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

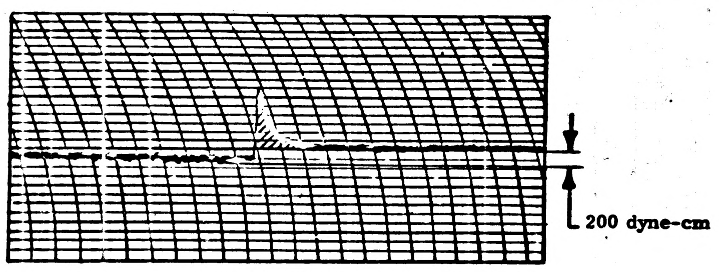


Fig. 5

Calculate cross hatched area of oil jog as called out in paragraph 2.1.2.3

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: Fred Straccia
DATE: 8/30/61
M. C. 25-900
SHEET 1
OF 1

CLEANING PROCESS FOR LAMINATIONS OF TRANSFORMER

NO. 58

A

B

1. Inspect for flatness, mechanical defects and uniformity of coating if applicable.
2. Wash laminations thoroughly in MEK (METHYL ETHYL KEYTONE) in an ultrasonic cleaner. A suitable cleaner is a Sonogen Ultrasonic Generator Mod. AP-25B with Transducer, Mod. LF-18-C by Branson Ultrasonic Corporation, Stamford, Connecticut.
3. Dry laminations in air in a dust free atmosphere or with material free from dust or lint.
4. Make sure that laminations are clean and store in clean, dry, lidded containers.

Rev. B 9/30/63

Rev. A 8/31/62

TDRR 14363 NOV 18 1964

INCHES
0 1 2
PHOTOGRAPHIC SCALE ONLY

APOLLO II IRIG Specification
MC 25-920
Release Date 21 July 69
Release Revision ——
Class A Release
TDRR 37699

Title: Evaluation of Apollo II Wheel in Float

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA

TP#11938

This MC specification consists of page 1 to ___ and 1 to 11 inclusive.

EVALUATION OF APOLLO II WHEEL IN FLOAT

1.0 General Requirements

The wheel evaluation in the float will be made over a 100 hour qualification period using rundown time reporting and power monitoring as the critical parameters.

1.1 Rundown Time Measurements

The wheel qualification rundown measurements shall be taken twice in each 24 hour period per MC 25-834 with a minimum of four (4) hours between rundowns. The total number of rundowns time measurements shall not be less than 8.

1.2 Power Monitoring

The wheel qualification power monitoring recording shall be performed during the entire 100 hour qualification period. Refer to MC 25-889 for the equipment specification. This recording shall be continuous except for interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

2.0 Float Disposition

After a minimum of 100 hours of wheel qualification, a disposition shall be made using the following criteria:

2.1 Rundown Time

2.1.1 The RMS of all wheel rundown times (σ_F) shall be equal to or less than 6.0 seconds.

2.1.2 The RMS calculations of the wheel rundown (σ_F) shall be calculated using the following:

$$\sigma_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = Average run-down time to 6000 rpm

n = Number of run-down time checks (no less than 8)

$T_1 \ldots T_n$ = Run-down time to 6000

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the float.

2.2 Power Monitoring Performance

The criteria for acceptance in the milliwattmeter evaluation lies in the interpretation of the recorded trace taken between each run-down time interval. In order to provide objectivity in this interpretation, reference will be made to a number of characteristic forms of the milliwatt trace and specifications or limits imposed on each. The following identification pertains to power traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. Milliwatt limits in this specification are based upon total power from both phases.

The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.

To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

2.2.1 Acceptable Power Traces

The principal requirement for an acceptable wheel is performance during the power monitoring period that is free of non-periodic or step power variations that are greater than 20 milliwatts. The maximum variation in mean power level shall not exceed 50 mw. Figs. 1a, b, c represent acceptable power traces. 1b and 1c indicate acceptable periodic power variations that are due to ball jump in both bearings.

The maximum allowable trace width during the monitoring period for an acceptable wheel is 40 mw. The maximum allowable variations in trace width during the total wheel power monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period between the fifth hour of running and first wheel rundown. The allowable increase is as indicated by the table below:

5th Hour to 1st RDT Average Milliwatt	Allowable Maximum Trace Width at Any Time Average Milliwatt
0-10	13
11-15	20
15-20	25
20-25	30
25-30	35
30-35	40
35-40	40

2.2.2 Provisionally Acceptable Power Trace

There are two categories of power variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

2.2.2.1 Test Equipment Influences

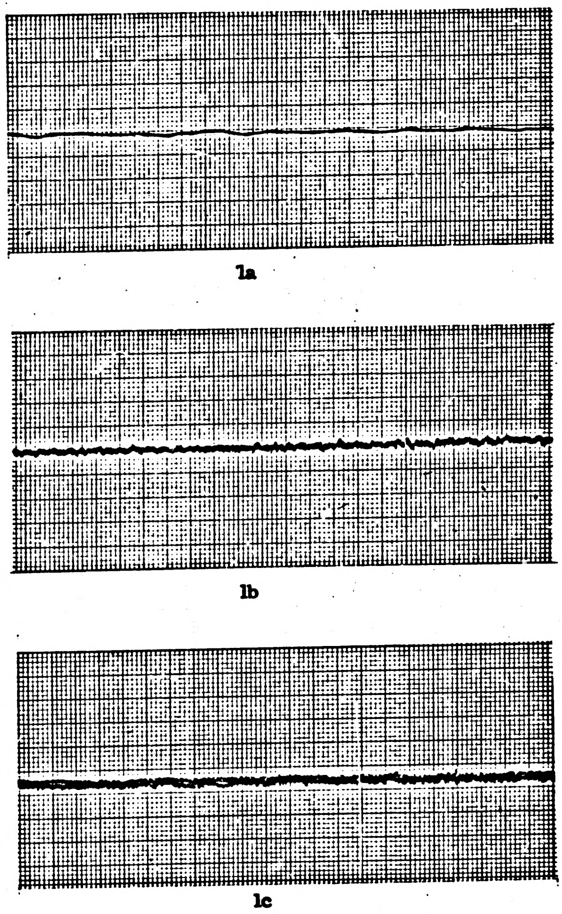
Fig. 2b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory power trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller then this component of the power trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

2.2.2.2 Oil Jogs

Fig. 2c is a typical power trace illustrating oil jogs. If the total integrated area of oil jogs within any one hour period is greater than 180 milliwatt-minutes, the wheel shall be rejected. NOTE: The procedure for calculating the area of oil jogs is as follows: Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area as illustrated by Fig. 4.

2.2.3 Non-Acceptable Power Trace

Any power trace resembling Fig. 3a-i are not acceptable in terms of of passing the intent of this specification. Typically the causes for rejection are excessive oil, (Fig. 3a) squeal (Fig. 3b), intermittent squeal (Fig. 3a), low preload (Fig. 3b, c), incipient varnish failure (Fig. 3b, c, d, e, f), debris (Fig. 3b, d, e), loose wires (Fig. 3b, c), one ball group unstable (Fig. 3c, b), equipment malfunction (Fig. 3i).


1a

1b

1c

Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time	
Constant	1.3sec ± 15%

Fig. 1 Acceptable Power Traces

Fig. 2a Deleted

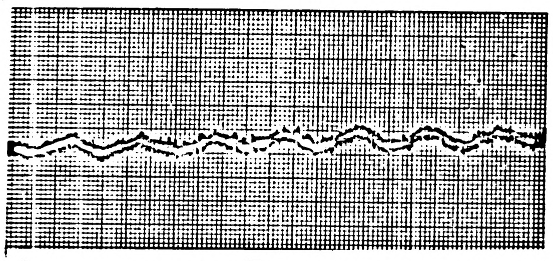
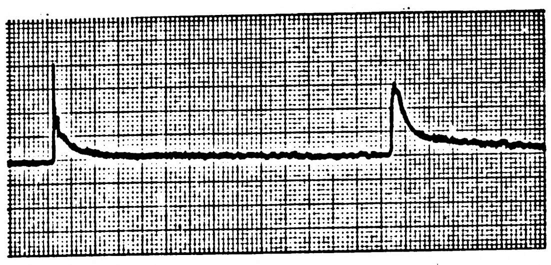

2b

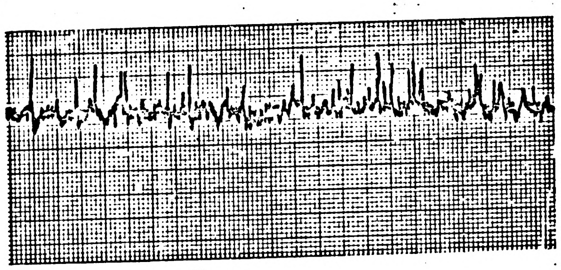
Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

Fig. 2 Provisionally Acceptable Power Traces.


2c

Instantaneous power increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

Fig. 2c Provisionally accepted power trace due to oil jog.

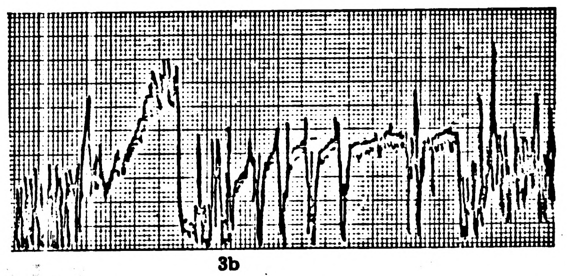

3a

Probable Cause
- Excessive Oil
- Intermittant Squeal

Instantaneous power increase caused by the retainer superimposed on a rough and irregular power trace.

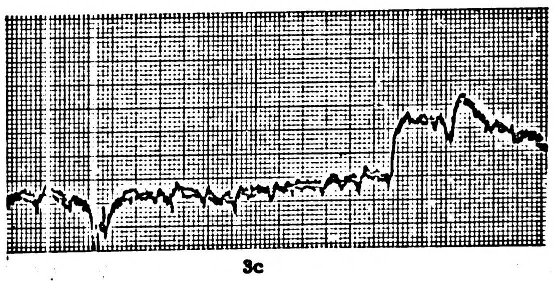
Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

Fig. 3 Non-Acceptable Power Traces.


3b

Probable Cause
- Loose Wire
- Retainer Squeal
- Low Preload
- Varnish
- Debris

Extremely irregular power trace that could be attributed to any or all of the listed causes singly or in combination.

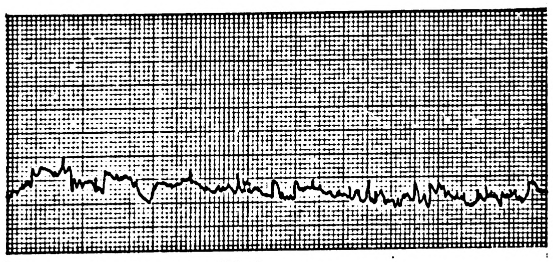

3c

Probable Cause
- Varnish
- Low Preload
- One Unstable Ball Group
- Loose Wires

Similar to 3c

Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time	
Constant	1.3 sec ± 15%

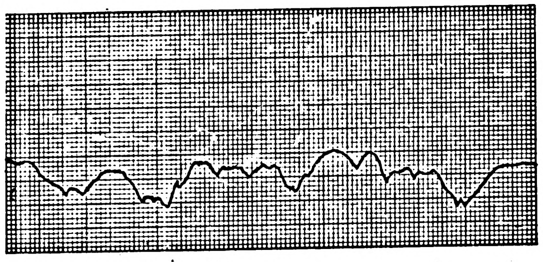
Fig. 3 (Cont.) Non-Acceptable Power Traces



3d

Probable Cause

Varnish Debris	This is typical of a varnish or debris induced power variation.



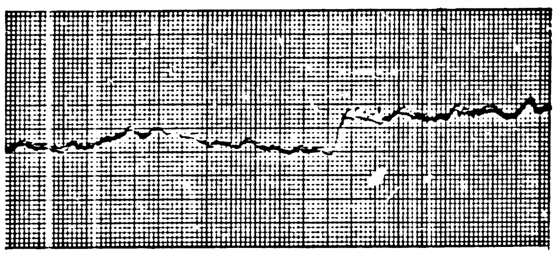
3e

Probable Cause

Varnish Debris	A power variation induced by debris or varnish, not as common as 3e but a positive indicator of an incipient failure.

Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time Constant	1.3 sec ± 15%

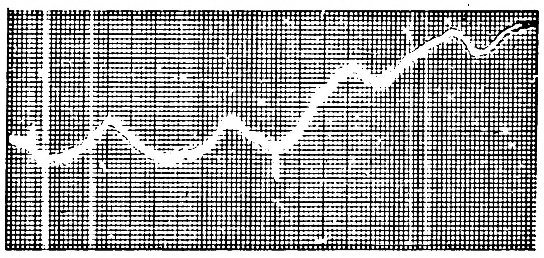
Fig. 3 (Cont.) Non-Acceptable Power Traces.



3f

Probable Cause

Slight Varnish	Early indication of a varnish build up on one or both bearings.



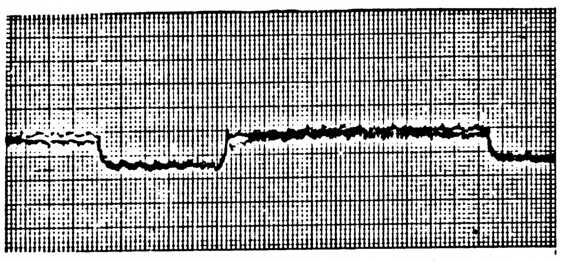
3g

Probable Cause

Varnish	This trace shows a steady increase in power with a superimposed sinusoid attributable to a temperature control cycle.

Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time Constant	1.3 sec ± 15%

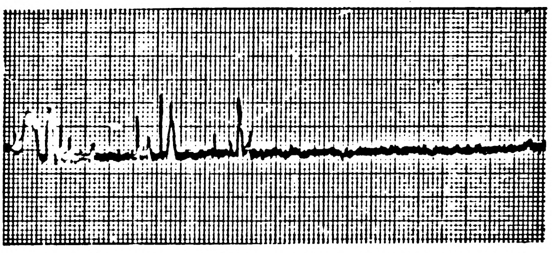
Fig. 3 (Cont.) Non-Acceptable Power Traces.



3h

Probable Cause

One Ball Group Changing Angular Velocity	Indicative of the wheel preload being too light ot control the angular velocity of the ball group in one bearing.



3i

Probable Cause

Squeal

Chart Speed	5 mm/min
Recorder Calibration	4 mw/mm
Recorder Time Constant	1.3 sec ± 15%

Fig. 3 (Cont.) Non-Acceptable Power Traces.

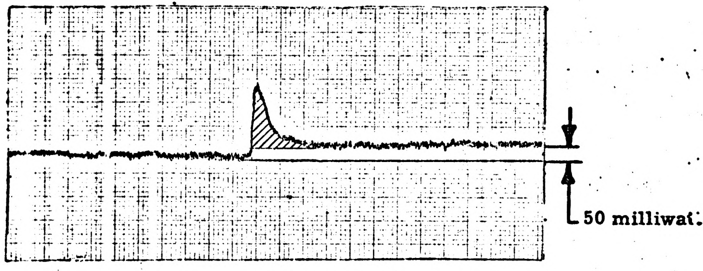


Fig. 4

Calculate cross hatched area of oil jog as called out in paragraph 2.2.2.3.

APOLLO II IRIG Specification
MC 25-921
Release Date 21 JULY 69
Release Revision ---
Class A Release
TDRR 37699

Title: Nylasint Retainer Processing Specification

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	NASA

This MC specification consists of page 1 to ___ and 1 to 4 inclusive.

TP#11938

Nylasint Retainer Processing Specification

1. Scope

This specification is intended as a guide to manufacture and prepare the nylasint retainer for final oil impregnation.

2. Impregnation of Retainer Slugs

a. Impregnate nylasint slugs (per SCD 2021819) with V-78 or V-79 oil and blot surfaces with lens tissue to remove excess surface oil.

3. Retainer Machining

a. Machine retainers from impregnated slugs per Dwg 2021829. Nylasint retainer machining procedure (MC 25-885) serves as a reference document to describe MIT's machining procedure.

4. Extraction of Oil

a. Oil shall be extracted from the retainers by subjecting them to a 12-hour continuous benzene flushing process utilizing a Soxhlet extractor or equivalent.

b. Vacuum bake for 1 hour minimum at 150°-160°F and 29 1/2 in.hg. minimum

5. Deburring of Retainers

a. Submerge retainers in liquid nitrogen and deburr using a dental drill and steel wool. (#00 supreme steel wool, Brillo Manufacturing Company Inc., Brooklyn, New York). The steel wool shall be ultrasonically cleaned in freon prior to use.

b. Scrub all surfaces with medium stiffness brush utilizing a mold detergent ("Sparkleen" manufactured by the Calgon Corp. has produced satisfactory results) and water to remove loose particles, contamination, and any steel wool.

c. Ultrasonically clean retainers in distilled water for two-five minute periods. (Change water after each period)

d. Inspect retainers for removal of burrs, contamination, and steel wool fibers under 30X magnification. Repeat steps a, b, or c, if necessary.

---

e. Ultrasonically clean retainers in freon for five minutes minimum.

f. Vacuum bake for one hour minimum at 150° -160°F and 29 1/2 in. hg. minimum.

6. Salt Blasting of Retainer Surfaces

a. The salt blasting equipment shall be capable of delivering a uniform flow rate of salt of 2.0 ± .5 grams/minute at a line pressure of 80 psi minimum. (Use International Salt Company - Sterling Grade CX salt.)

b. Keeping the nozzle approx. 1/8" to 1/2" away from retainer surface, blast the retainer surface as indicated:

Surface Description	Exposure Time(Tolerance: ±5 sec)
Ball Pockets	2 min. each pocket
Outer Diameter	2 min. total
Edges	2 min. each edge
Inner Diameter	20 sec. total

NOTE: The nozzle distance should be chosen so that the retainer will appear "burnished" after blasting without erosion of nylasint. Caution should be exercised to minimize material removal other than loose or extruding burrs.

c. Ultrasonically clean retainers in distilled water for three-five minute periods (change water after each period)

d. Ultrasonically clean retainers in freon for one-five minute period.

e. Vacuum bake retainers for one hour minimum at 130° - 150°F and 25-50 microns.

f. Equipment
S. S. White Industrial Abrasive unit
model G
201 East 42nd Street
New York, N. Y. 10017 or equivalent
NOTE: Handpiece 351-1793y (approx .040 dia) without nozzle attachment shall be used as a nozzle

7. Final Clean and Inspect

a. Burrs and/or smeared extruding nylasint caused by burnishing shall be removed by cutting with X-acto blade.

b. Ultrasonically clean retainers in freon for five minutes minimum.

---

c. Finally inspect retainer for absence of burrs, contamination, and damage under 30X magnification.

d. Holes from pull out of solid nylon inclusions will be permitted on the O.D. surfaces and side edges of the retainer processed to dwg. 2021829. Pull out at the edges of the ball pocket surfaces which intersect the O.D. and I.D. surfaces will be permitted provided that the surface area caused by the pull out is blended to meet the I.D. and O.D. surface and the ball pocket surface. The depth of blend may not exceed 0.010 inches into the ball pocket or the O.D. or I.D. surface. (See fig. 1.)

e. Hard particles are acceptable at any surface of the retainer if they do not protrude above the surrounding surface and are firmly anchored in the base material. No inclusions will be permitted where ball makes contact in pocket. NOTE: Hard particle inclusions are nylon particles that have a white to yellow color and have a smooth somewhat glossy surface when machined through.

f. Dark (brown and black) inclusions are acceptable only if they are imbedded below the surface of the retainer surface.

8. Oil Absorption Test

a. Check retainers for oil absorption test per MC 25-713.

b. After oil absorption test reclean the retainers per paragraphs 6c, 6d, and 6e of this specification.

9. General Notes

a. Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

b. When not actually being worked on, the material and/or retainers should be stored in a covered pyrex dish using desiccants to minimize the humidity of the storage environment.

c. The only solvents to be used with nylasint are freon, reagent grade, benzene, and distilled water.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: B. Rockower
DATE: 24 June 1969
MC 25-921
SHEET 4
OF 4

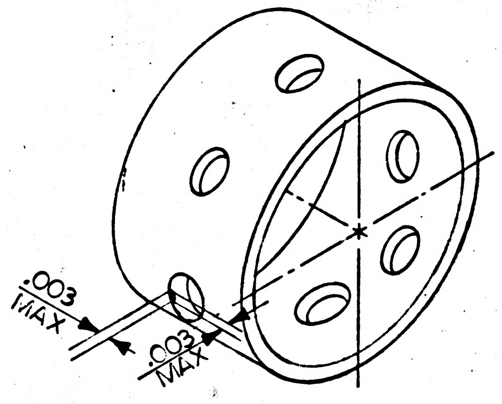
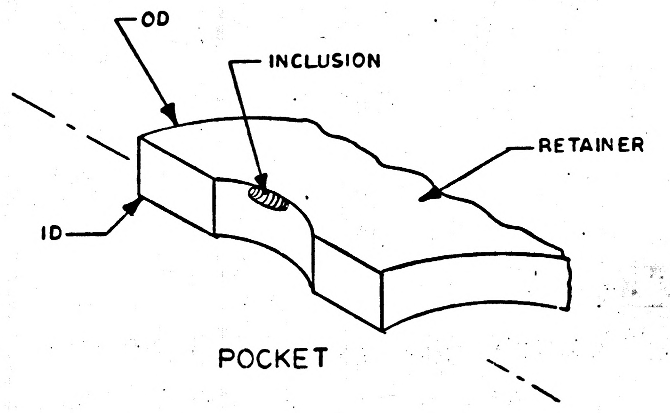

.003
MAX
.002
MAX

FIG 1
BALL POCKET BLEND


OD
INCLUSION
RETAINER
ID

POCKET

APOLLO II IRIG Specification
MC 25-916
Release Date 9 Apr. '69
Release Revision —
Class A Release
TDRR 37478

Title: Apollo II Bearing Race Alumina TCP Refinishing Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA

TP#11938

This MC specification consists of page 1 to ___ and 1 to 5 inclusive.

Apollo II Bearing Race Alumina TCP Refinishing Procedure

1.0 MATERIALS

1.1 Alumina Oxide, Micro Grit, Micron Size #3, Geoscience Instrument Company, Mt. Vernon, New York.

1.2 Alumina Oxide, Micro Grit, Micron Size #1, Geoscience Instrument Company, Mt. Vernon, New York.

1.3 TCP per SCD C-1008993

1.4 Fisher Lens Paper No. 11-996

1.5 Kenwood 6" Cotton-tipped Wooden Applicators, #11-0830, Will Ross, Inc., Milwaukee, Wisconsin.

2.0 PREPARATION OF LAPPING MIXTURES

2.1 Place 0.20 ± 0.02 grams of micron grit size #3 powder into a clean petri dish or other suitably cleaned container.

2.2 Using a syringe, add 0.10 - 0.15 cc of TCP. Stir until a heavy cream solution is obtained.

2.3 Keep solution well covered to prevent foreign contaminants from entering the mixture.

2.4 Prepare a second mixture in the same manner using micron grit size #1 powder.

3.0 LAPPING PROCEDURE

3.1 Clean bearings per MC 25-878.

3.2 Inner Races

3.2.1 To prevent scratching or marring, wrap mylar tape, teflon sleeving,or other protection once around diameter of shaft. Ensure that the protection does not overlap and cause bearing misalignment. With bone tweezers, place shaft into the collet of a jeweler's lathe (or other suitable machine shop lathe) and clamp securely.

NOTE: Extreme caution should be taken in guiding shaft into the collet to prevent any damage to bearing raceway.

NOTE: As an alternative to the use of a collet, shaft may be placed between centers.

3.2.2 Form the wooden applicator to the dimensions of Figure 1.

3.2.3 Rotate the shaft in a clockwise direction (looking in on piece) at 120 ± 10 RPM. Dip applicator stick into micron grit size #3 lapping mixture and, using very light finger pressure, place it on raceway at approximately a 45° angle from the shaft axis. (See Figure 2) Using a slow back and forth radial sweeping motion, work raceway for 2 ± 1/4 minutes. Avoid letting the stick climb over and onto center body diameter of shaft.

3.2.4 Shave off used portion of applicator stick and rework a new edge.

3.2.5 With lathe running at the same RPM, double wrap applicator stick with lens paper and wipe out excessive lapping residue from raceway.

3.2.6 Repeat Para. 3.2.3 through 3.2.5 ten (10) more times.

3.2.7 Rotate shaft counter clockwise at 120 ± 10 RPM and repeat the finishing procedure of Para. 3.2.3 through 3.2.5.

3.2.8 Rotate the shaft in a clockwise direction at 120 ± 10 RPM. Dip applicator stick into micron grit size #1 lapping mixture and, using very light finger pressure, place it on raceway at approximately a 45° angle from the shaft axis. (See Figure 2) Using a slow back and forth radial sweeping motion, work raceway for 30 ± 5 seconds. Avoid letting the stick climb over and onto center body diameter of shaft.

3.2.9 Shave off used portion of applicator stick and rework a new edge.

3.2.10 With lathe running at 500 ± 20 RPM, double wrap applicator stick with lens paper and wipe out excessive lapping residue from raceway.

3.2.11 Stop lathe, remove shaft, and clean per MC 25-878.

3.2.12 Examine raceway under 30X magnification. If pits, scratches, stringers, etc. exceed the limits specified in MC 25-887, place shaft back in lathe in manner previously described and repeat Para. 3.2.3 through 3.2.5. Repeat Para. 3.2.8 through 3.2.11.

3.2.13 Repeat Para. 3.2.12 until a finish is obtained which meets the requirements of MC 25-887.

3.3 Outer Races

3.3.1 Using bone tweezers, place outer race in a collet so that the stamped end is facing outward and is visible to the operator. This provides ready access to the contact surface. (See Figure 3) Ensure that the unstamped end of the outer race fits flush with the back of the collet.

3.3.2 Repeat Para. 3.2.2 through 3.2.13 for the portion of the raceway from the center of the race to the land diameter on the unstamped end.

4.0 CLEANING

4.1 When refinishing of bearing has been completed, clean bearing ultrasonically for at least five (5) minutes in Toluene. Demagnetize and vacuum dry.

4.2 Wrap lens paper around applicator stick, dip in Toluene, and wipe bearing vigorously, concentrating on the contact area.

4.3 After every two or three wipes, relocate lens paper so that a clean portion of the paper covers the tip of the applicator stick. Re-dip in Toluene. This process should continue until the lens paper remains clean during wiping.

4.4 Clean bearing per MC 25-878.

4.5 Insert entire bearing including balls into the Acetone Soxhlett Extractor. Extract for at least eight (8) hours. Remove bearing from Soxhlett extractor and dry rapidly over a vacuum hose. To prevent staining, place the bearing in a beaker of acetone while transporting it from the extractor to the vacuum hose.

4.6 Clean bearing per MC 25-878.

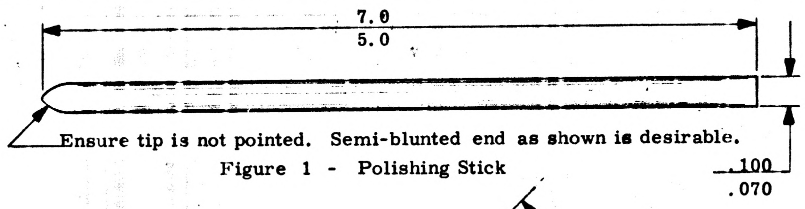

7.0
5.0
Ensure tip is not pointed. Semi-blunted end as shown is desirable.
.100
.070

Figure 1 - Polishing Stick

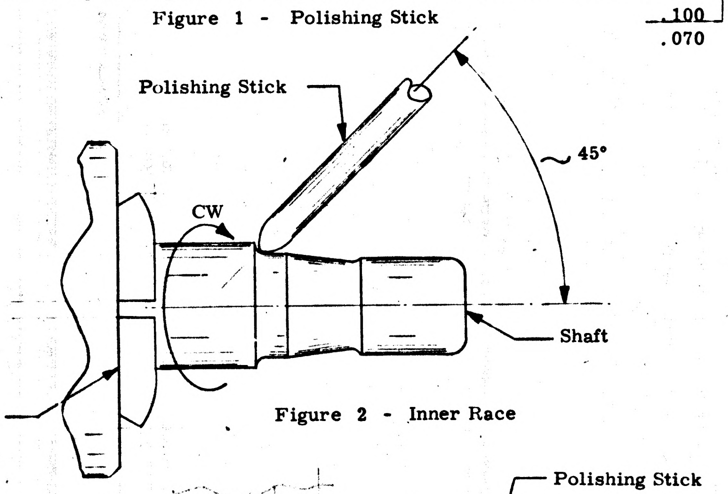

Polishing Stick
45°
CW
Shaft
Collet

Figure 2 - Inner Race

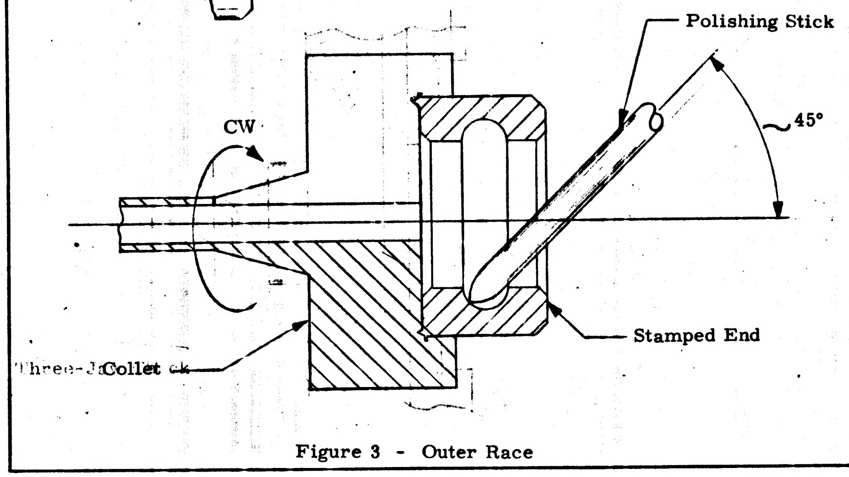

Polishing Stick
45°
CW
Stamped End
Collet

Figure 3 - Outer Race

APOLLO II IRIG Specification
MC 25-919
Release Date 21 July '69
Release Revision —
Class A Release
TDRR 37699

Title: Evaluation of Apollo II Wheel in Dynamometer

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA

This MC specification consists of page i to ___ and 1 to 17 inclusive.

TP#11938

Evaluation of Apollo II Wheel in Dynamometer

1.0 Temperature Cycle Test

Before evaluating the wheel over the 200 hour qualification period, the wheel shall be run at synchronous speed for the periods of time and at the operating temperatures specified below.

Period of Time	Operating Temperature
24 ± 12 hours	137 °F
6 ± 1/2 hours	125 °F
24 ± 1 hours	160 °F

Dynamometer performance may be monitored during this period but is not a specification requirement. After running wheel at above temperatures, remove wheel from dynamometer and visually inspect both bearings under 30X microscope. Examine both bearings for any evidence of incipient varnish build up on either retainer ball pockets or raceways. Also examine for any discoloration of raceways or balls. Any evidence of varnish or discoloration is cause for rejection of the wheel assembly. Also check for presence of oil meniscus between balls and inner race. If meniscus is not present, use 0.002 diameter platinum wire to add $0.010^{+.000}_{-.002}$ diameter drop of oil (per SCD 2021827) to ball or inner race.

2.0 General Requirements

The wheel evaluation test will be made on wheels which pass the temperature cycle test described above. Wheel evaluation will be made over a 200 hour qualification period using rundown time measurement, breakaway voltage measurement, minimum voltage to synchronous speed and torque monitoring as the critical parameters. During qualification, wheel shall be operated in ambient of one half atmosphere of helium. Alternate: 5.0 psig helium. Prior to setting ambient, dynamometer fixtures shall be evacuated to 20 in. mercury vacuum and back filled with helium to one atmosphere. Repeat evacuation and backfill five times minimum.

2.1 Rundown Time Measurements

The wheel qualification rundown time measurements shall be taken twice in each 24 hour period with a minimum of four (4) hours between rundowns. After the first 50 hours of wheel qualification a minimum of one rundown time measurement may be taken in each 24 hour period except on weekends or holidays. The total number of rundown time measurements shall not be less than 12. To measure rundown time, switch off wheel momentarily

---

to dissipate any overexcitation and proceed per MC 25-834. Wheel operating temperature and other rundown data shall be recorded on MC-811.

2.2 Breakaway Voltage Measurements

The wheel qualification breakaway voltage measurements shall be made per MC 25-873 once every 24 hours during the qualification period. Record data on MC-811.

2.3 Minimum Voltage to Reach Synchronous Speed

The wheel must be capable of reaching synchronous speed at 26.6 volts. Minimum voltage measurements shall be made once every 24 hours during the qualification period. Record data on MC-811.

2.4 Torque Monitoring

The wheel qualification torque monitoring recording shall be performed during the entire 200 hour qualification period for acceptable wheels. Refer to MC 25-888 for the wheel qualification equipment specification. The recording shall be continuous except for interruptions due to scheduled rundown time measurements and interruptions caused by equipment failures. The usable portion of this recording excludes the first hour after any interruption.

3.0 Disposition Points

There are two formal points in time for making wheel dispositions, namely the fiftieth and the two hundredth hours of wheel operations. Fig. 1 serves to clarify the use of these formal disposition points and indicates a wheel qualification program yield history. Dispositions at points other than the 50th and 200th hour are allowed but not required.

3.1 Fifty Hour Disposition

Within 24 hours after the completion of the first 50 hours of wheel qualification a disposition shall be made using the following criteria.

3.1.1 Rundown Time Repeatability

If the maximum difference between the four (4) rundown time measurements is greater than 10 seconds, two more measurements shall be taken at 15 min. minimum intervals to determine if rundown time is bad or if level is actually changing. Final disposition shall be made after 200 hours using all rundown time measurements (See para. 2.1).

3.1.2 Torque Monitoring Performance

The criteria for acceptance in the dynamometer evaluation lies in the interpretation of the recorded trace taken between each rundown time interval. In order to provide objectivity in this interpretation reference will be made to a number of characteristic forms of the dynamometer trace and specifications or limits imposed on each. The following identification pertains to dynamometer traces in what is considered to be the acceptable, provisionally acceptable and non-acceptable categories. The torque stability requirements of this specification reasonably define the performance requirements for qualification of wheel assemblies. However, all possible anomalies, characteristics and conditions cannot be anticipated. Therefore, recognizing that the intent of the specification is to preclude the acceptance of wheels with metal defects, contamination, dynamic instabilities and any other condition that could impair wheel life, the contractor shall establish a practice for his formal review of wheels considered for acceptance using the specification as a guide. This plan for the formalized review by the contractor of wheels that deviate from the specification must be approved by the procuring agency.
To this end, acceptance of wheels with variations to this specification is permitted without waiver, provided that a formal review according to the approved plan has been made in each case.

3.1.2.1 Acceptable Torque Trace

The principal requirements for an acceptable wheel is performance during the monitoring period that is free of non-periodic or step torque variations greater than 75 dyne-cm. Fig. 2a,b,c represent acceptable torque traces with 2b and 2c indicating acceptable periodic variations. (The variations are due, in this case, to ball jump in both bearings.)

The maximum allowable trace width during the monitoring period for an acceptable wheel is 150 dyne-cm. The maximum allowable variation in trace width during the total wheel monitoring period shall be based on a comparison of the largest trace width at any time during the monitoring period compared to the level exhibited during the period between the fifth hour of running and the first wheel rundown. The allowable increase is as indicated below.

5th Hour to 1st RDT Average Dyna. Torque	Allowable Maximum Trace Width at Any Time Average Dyna. Torque
25	75
50	100
75	100
100	125
125-150	150

3.1.2.2 Provisionally Acceptable Torque Trace

There are two categories of torque variation occurring during the qualification period that may be considered acceptable under particular modifying conditions.

3.1.2.2.1 Torque Level Disturbance

Fig. 3a is typical of torque trace exhibiting a disturbance of the torque level for a short period of time (less than 10 minutes). This characteristic is acceptable provided that it occurs no more than once during the 50 hour qualifying period as shown in Figure 1.

3.1.2.2.2 Test Equipment Influences

Fig. 3b illustrates the superposition of a long period sinusoid onto an otherwise satisfactory torque trace. If the period of the sinusoid (normally 5 to 15 minutes) can be shown to be the same as the period of the temperature controller than this component of the torque trace can be disallowed and the wheel accepted providing that it meets the other requirements of this specification.

3.1.2.3 Oil Jogs

Fig. 3c is a typical torque trace illustrating oil jogs. If the total integrated area of oil jobs within any one hour period is greater than 720 dyne-cm-minute, the wheel shall be rejected.

NOTE: The procedure for calculating the area of oil jogs is as follows:
Extend a straight line from point at end of jog where trace levels off to beginning of jog where trace increases vertically. Calculate the cross hatched area illustrated by Figure 5.

3.1.2.4 Non Acceptable Torque Trace

Any torque trace resembling Fig. 4a-i are not acceptable in terms of passing the intent of this specification. Typically the causes for rejection are squeal (Fig. 4b), intermittent squeal (Fig. 4a), low preload (Fig. 4b, c), incipient varnish failure (Fig. 4b, c, d, e, f), debris (Fig. 4b, d, e), loose wires (Fig. b, c), one ball group unstable (Fig. c, h), equipment malfunction (Fig. 4i).

3.1.2.5 Retainer Stability Motion Study

If a wheel is rejected because of non-acceptable torque trace, retainer motion shall be observed to assist in determining reason for wheel failure. Place wheel in milliwattmeter fixture (drawing E-159826). Wheel shall be [illegible]

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operated in ambient one-half atmosphere helium or 5 psig and at operating temperature (137°F). Run wheel up to synchronous speed. Adjust binocular microscope (American Optical or equivalent) to 10 power and focus on one of the retainers of running wheel. With variable oscillator, externally trigger stroboscope with sufficient excitation to fire stroboscope and electronic counter. Set oscillator at retainer frequency (Ref. 243 Hz) and aim stroboscope at bearing as close as possible. Adjust oscillator until retainer appears to "stop" and observe stability of motion. Continue observation with retainer slowly drifting for possible signs of erratic behavior. Repeat observations with second bearing.

3.1.2.6 Other dynamometer requirements

The maximum variation in mean torque level shall not exceed 200 dyne-cm. The minimum allowable torque level shall be 800 dyne-cm (normal range 800-1800 dyne-cm, reference only)

3.2 Two Hundred Hour Disposition

After a minimum of 200 hours of wheel qualification a disposition shall be made using the following criteria.

3.2.1 Rundown Time

3.2.1.1 The RMS of all wheel rundown times (σ_D) shall be equal to or less than 5 seconds.

3.2.1.2 The RMS of the wheel rundown time (σ_D) shall be calculated using the following

$$\sigma_D = \sqrt{\frac{(T_1 - A_D)^2 + (T_2 - A_D)^2 + \ldots\ldots (T_n - A_D)^2}{n}}$$

A_D = Average run-down time to 6000 rpm

n = Number of run-down checks (no less than 12)

$T_1 \ldots T_n$ = Run down time to 6000 rpm

Note: Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection etc.); then, if the condition continues, reject the wheel assembly.

3.2.2 Breakaway Voltage Measurement Comparison

The breakaway voltage at the beginning and end of the wheel qualification period should be examined. Although no specification requirement is imposed herein, this information should be examined along with the rundown times and torque traces. Like decreasing rundown times, a significant increase of breakaway voltage is indicative of incipient bearing failure.

3.2.3 Torque Monitoring Performance

The criteria of section 3.1.2 are to be applied to the 200 hour disposition.

3.2.4 Synchronous Voltage Measurement Comparison

Minimum voltage to reach synchronous speed at the beginning and end of the wheel qualification period should be compared. This information should be examined along with breakaway voltage measurements, rundown times and torque traces for any indication of incipient bearing failure.

3.2.5 After removing wheel from dynamometer, visually inspect both bearings under 30X microscope. Examine both bearings for any evidence of incipient varnish build up on either retainer ball pocket or raceways. Also examine for any discoloration of raceways or balls. Any evidence of varnish or discoloration is cause for rejection of the wheel assembly. Bearings shall also be inspected for presence of an oil meniscus between balls and inner race. This examination for the presence of a meniscus should be done within an hour at most from the last wheel running period. The absence of a meniscus is considered serious and either rejection of the wheel or suitable corrective action under the direction of the gyro wheel review committee shall be the indicated appropriate action. Suitable corrective action can include further oil addition and continued dynamometer running time followed by an additional visual examination.

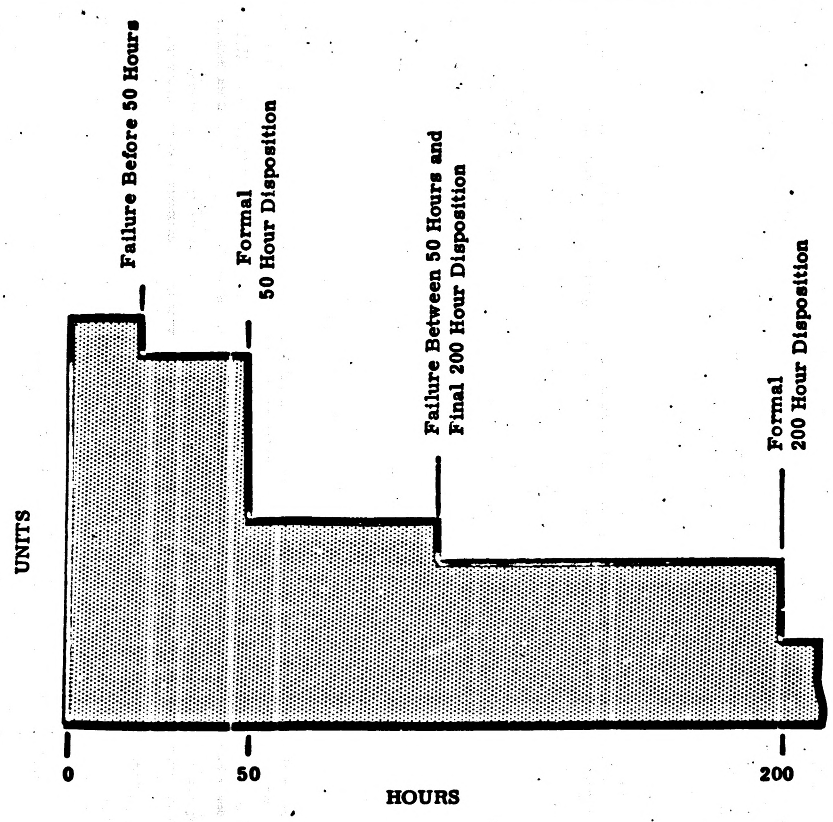


Fig. 1 Illustrative Wheel Qualification Program Yield History.

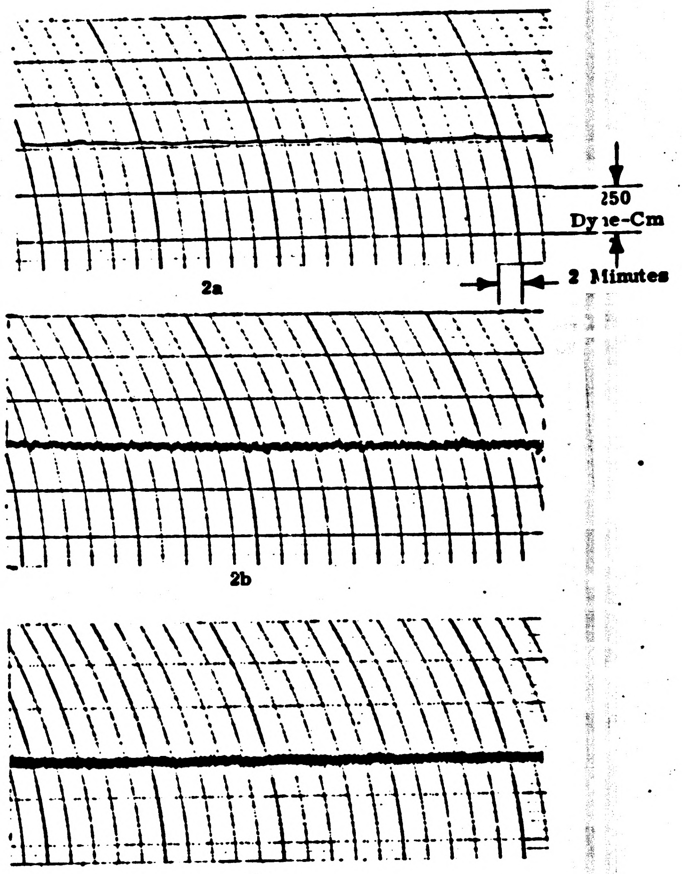


Chart Speed	6 inches/Hour *
Recorder Calibration	25 D.C./mm
Recorder Time Constant	0.3 sec ± 15%

Fig. 2 Acceptable Torque Traces
* Chart information applicable to figures 2, 3, 4.

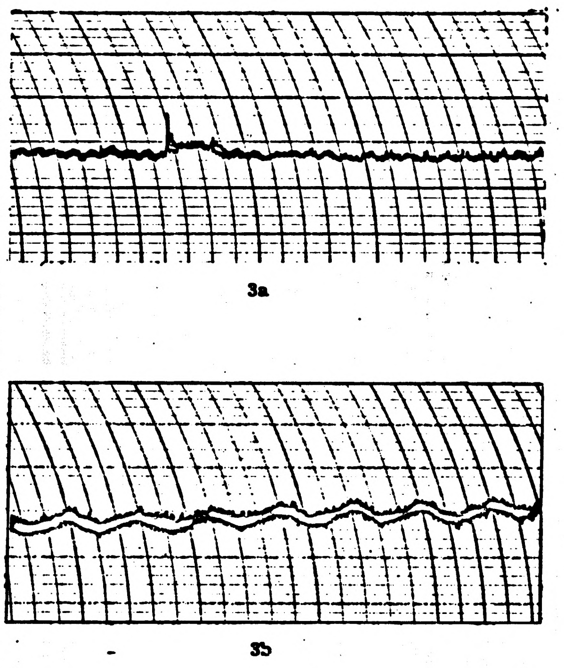
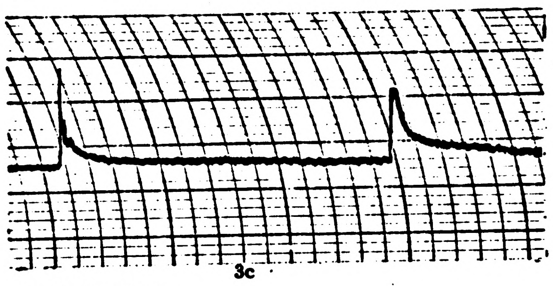


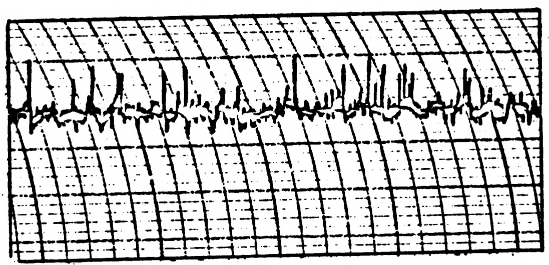
Fig. 3 Provisionally Acceptable Torque Traces



3c

Probable Cause
Oil jog

Instantaneous torque increase and gradual decay caused by an excess of lubricant being thrown into the ball track.

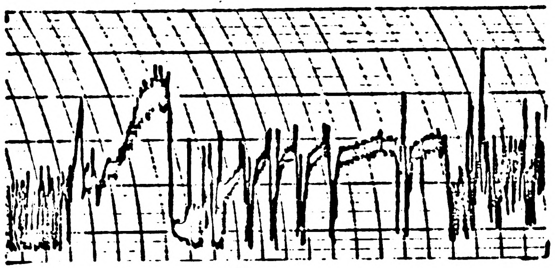


4a

Probable Cause
Excessive Oil
Intermittent Squeal

Instantaneous torque increase caused by the retainer superimposed on a rough and irregular power trace.

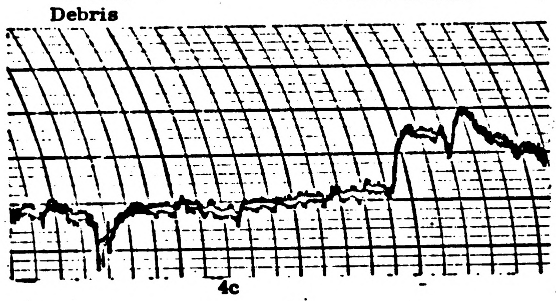
Fig. 4 Non-Acceptable Torque Traces.



4b

Probable Cause
Loose Wire
Retainer Squeal
Low Preload
Varnish
Debris

Extremely irregular torque trace that could be attributed to any or all of the listed causes singly or in combination.

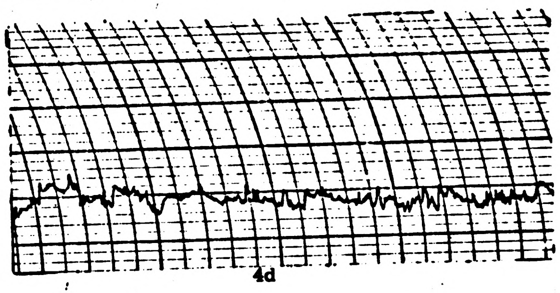


4c

Probable Cause
Varnish
Low Preload
One Unstable Ball Group
Loose Wires

Similar to 4b

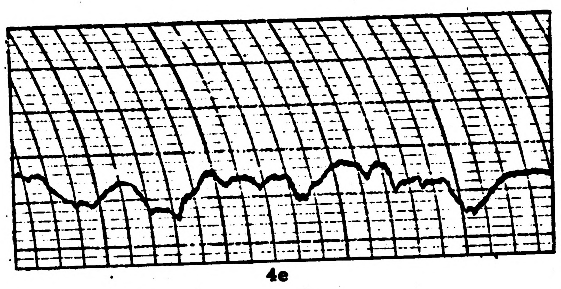
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4d

Probable Cause
Varnish
Debris

This is typical of a varnish or debris induced torque variation.

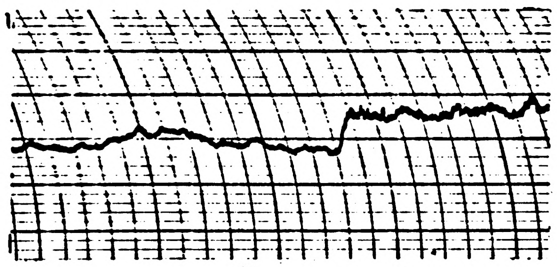


4e

Probable Cause
Varnish
Debris

A torque variation induced by debris or varnish, not as common as 4e but a positive indicator of an incipient failure.

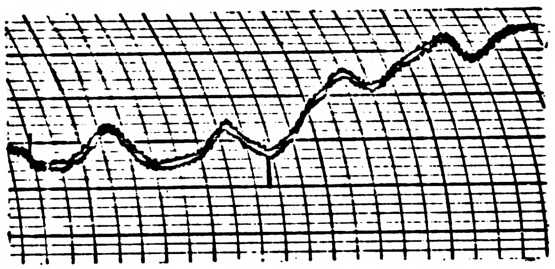
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4f

Probable Cause
Slight Varnish

Early indication of a varnish build up on one or both bearings.

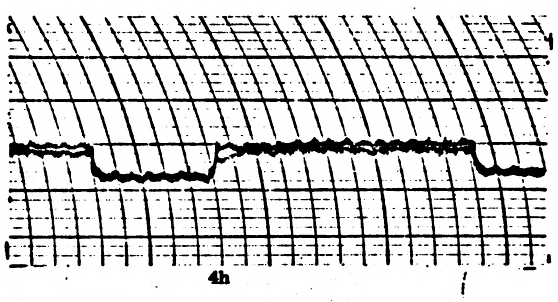


4g

Probable Cause
Varnish

This trace shows a steady increase in torque with a superimposed sinusoid attributable to a temperature control cycle.

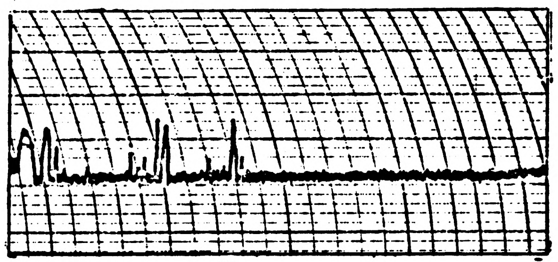
Fig. 4 (Cont.) Non-Acceptable Torque Traces.



4h

Probable Cause

One Ball Group Changing Angular Velocity	Indicative of the wheel preload being too light to control the angular velocity of the ball group in one bearing.



4i

Probable Cause

Equipment	The torque variation is directly related to an equipment problem and repair of equipment is necessary before proceeding with qualification of this wheel.

Fig. 4 (Cont.) Non-Acceptable Torque Traces.

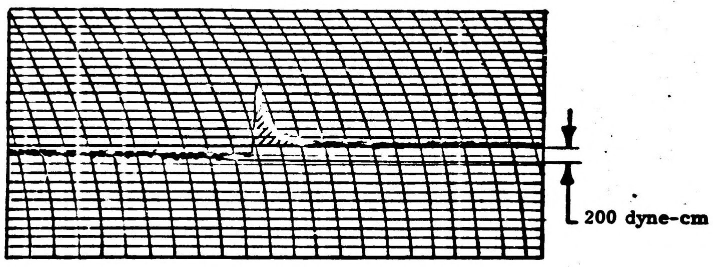


Fig. 5

Calculate cross hatched area of oil jog as called out in paragraph 2.1.2.3

APOLLO II IRIG Specification
MC 25-850
Release Date 18 Nov. 1964
Release Revision -
Class A Release
TDRR 14363

Unit Flotation Test

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
6/8/65	A	20016	1, 2	WK	

TP#11938

This MC specification consists of page 1 ~~to~~ ___ and 1 to 3 inclusive.

Rev A 6-3-65

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CAMBRIDGE, MASS.
PREPARED BY: Louis Bertolami
DATE: February 25, 1964
MC 25-850
SHEET 1 OF 3

Title: Unit Flotation Test
Equipment: North Atlantic Phase Angle Voltmeter VM 204 or Equivalent
Note: All voltage measurements are made with a phase angle voltmeter to insure in phase voltages are measured.

I. Unit Orientation: IA Horizontal, + SRA up

1. With the unit excited as required in procurement specification, stabilize for at least 30 minutes.

   Record the radial voltages (Sx, Sy, Tx, Ty) on chart I.

II. Unit Orientation: IA Horizontal + SRA Down

2. Allow radial signals to settle for at least 10 minutes and record voltages (Sx, Sy, Tx, Ty).

   NOTE: By varying the temperature and noting the radial voltage drift, you can determine whether flotation is above or below operating temperature. It is advisable but not absolutely necessary to have the sample temperatures on either side of flotation.

A

3. Change temperature approximately 2°F from normal operating temperature in the direction as determined above.
4. Repeat step 1.
5. Repeat step 2.
6. Obtain from chart I the radial voltage differences for each axis and plot on graph I.
7. Draw straight lines connecting the two temperature radial difference measurements for each axis (Sx, Sy, Tx, Ty).
8. Note the zero crossover points of each radial axis and average the temperatures indicated. This is the flotation temperature.

TDRR 14363 NOV 18 1964

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DATE: February 25, 1964
MC 25-850
SHEET 2 OF 3

CHART 1

GYRO ORIENTATION IA HORIZONTAL			RADIAL VOLTAGES			
			S_X	S_Y	T_X	T_Y
OPERATING TEMP.	RES. ____	SRA UP				
		SRA DN				
	TEMP. ____	DIFF				
APPROX. + 2°F	RES. ____	SRA UP				
		SRA DN				
	TEMP. ____	DIFF				
APPROX - 2°F	RES. ____	SRA UP				
		SRA DN				
	TEMP. ____	DIFF				

FLOTATION TEMPERATURE ______ °F; ______ Ω

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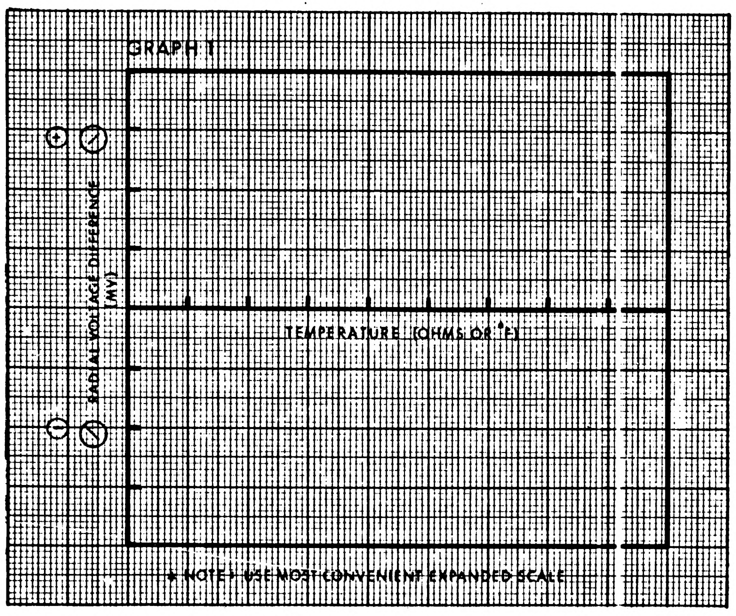

APOLLO II IRIG Specification
MC 25-862
Release Date 25 Nov. 1964
Release Revision A
Class A **Release**
TDRR 14531

ASSEMBLY PROCEDURE FOR SUSPENSION

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
3/18/65	B	17644	1, 2, 3	WK.	WJR

TP#11938

This MC specification consists of page i to____and 1 to 3 inclusive.

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CAMBRIDGE, MASS.

PREPARED BY: D. Freeman
D. Zickefoose
DATE: February 25, 1964

MC25-862

SHEET 1
OF 3

Rev A 10-30-64
RevB 3-18-65

ASSEMBLY PROCEDURE FOR SUSPENSION, APOLLO II IRIG

1.0 Core Winding Preparation

A 1.1 Assemble winding arbor B-82382 (2 parts) with suspension core A-2021686. Be sure to assemble winding fixture so that winding arbor extension can be used if needed.

2.0 Suspension Core Winding

2.1 Suspension can be hand wound or machine wound.

A 2.2 Winding direction, number of turns per pole, type, and size wire are given on 2021657.

2.3 Coil pair ends shall come out on Small Dia. side of suspension core.

2.4 Strip coil lead ends approximately 1/2" from end.

2.5 With an ohmmeter check each coil pair for grounding to core upon completion of winding. Identify Pole #1.

2.6 Determine pole-pair ends by continuity method and twist individual coil pair ends together to keep separated.

2.7 Measure coil-pair resistances with a Wheatstone Bridge. The four Resistance readings shall have a spread of 5% max.

3.0 Forming

A 3.1 Insert slot papers 2021584 in each slot. Use nonmetallic instrument for forming.

3.2 Trim slot papers to approximate length as shown.

3.3 Form coils by sliding forming fixtures over winding arbor until forming fixture ends are flush with winding arbor ends.

3.4 Most units do not require forming but it is a good idea to run through the steps anyway.

4.0 Lead out Wire Assembly

4.1 Slots where lead out wires are to be inserted require 2 slot papers. Follow same procedure as previously outlined.

4.2 Make lead out wire clearance hole between slot papers with a non-metallic instrument.

4.3 Strip lead out wires 1/8" back from end and tin (60-40 Solder Kester 1571 Flux). Push lead out wires up between slot papers until 1/2" is protruding above coil.

4.4 Strip and solder (60-40 Solder Kester Flux) coil end wires to appropriate lead out wires. Trim excess lead out wire for smooth joint.

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PREPARED BY: D. Freeman, D. Zickefoose SHEET 2
DATE: February 25, 1964 MC 25-862 OF 3

4.5 Pull lead out wires back so that solder connection is below surface of coils.

4.6 Remove Winding Arbor.

4.7 Wash unit ultrasonicially in synthetic Methanol for approximately 1 minute to remove flux residue then wash ultrasonically in freon for approximately 10 minutes.

5.0 Preliminary electrical tests

A 5.1 Make polarity check per 2021657. Make insulation tests with 250V megohmmeter DC(500 megohns minimum).

6.0 Final Lead Out Wire Assembly

B 6.1 Apply LCA-9 to top and bottom of coil slot to secure the lead out wire.

BA 6.2 Apply thin coating of LCA-9 on common coil lead that runs across top of other coils.

6.3 Cure Assembly for 2 1/2 hours at 180°F.

7.0 Prepot Electrical Tests

7.1 Perform Shorted turn test.

7.1.1. Connect and excite per Fig 1,

7.1.2 Series tune each of four coil pairs, recording V in and C at resonance.

7.1.3 The 4 V in readings shall be within 5% of one another and the capacitors spread shall be 5% maximum.

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PREPARED BY: **D. Freeman, D. Zickefoose** SHEET 3
DATE: **February 25, 1964** **MC 25-862** OF 3

B [illegible] Check magnetic characteristics per MC 25-[illegible]

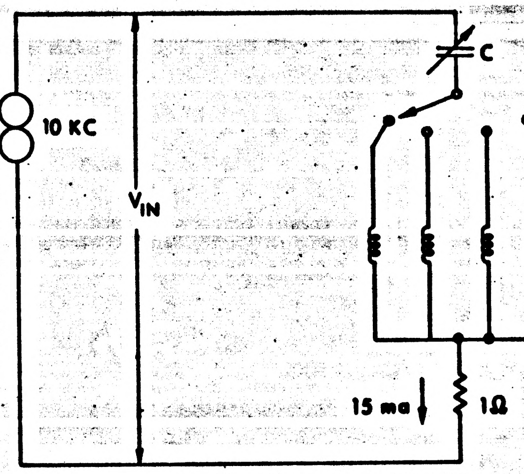

FIG. 1

APOLLO II IRIG Specification
MC 25-859
Release Date Nov. 25, 1964
Release Revision A
Class A **Release**
TDRR 14531.

Procedure for Testing
SG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/12/65	B	16568	1, 2	WR	2/17/65
3/18/65	C	17645	2, 2	WR	WJR

TP# 11938

This MC specification consists of page i
___and 1 to 2 inclusive.

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CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

MC 25-859

SHEET 1
OF 2

Rev. A 11/9/64 Rev. B 2/12/65 Rev. C 3/18/65

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5°F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Figure 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

2.4 Adjust axial height of stator until I_m lags V_1 by $45^\circ \pm 1^\circ$ and
B I_m = 41.5 ± 3 ma.

A 2.5 Disable SG primary and measure suspension reaction torque.
B Record. Limit is 0 ± 0.15 dyne-cm.

3.0 Signal Generator

B 3.1 Reconnect per Fig. 1. Disable suspension, and increase V_{in} to 4.0 v.

3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating
A and recording the angular sensitivity and relative phase of E_o vs V_{in}.

TDRR 14531 NOV 25 1964

PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

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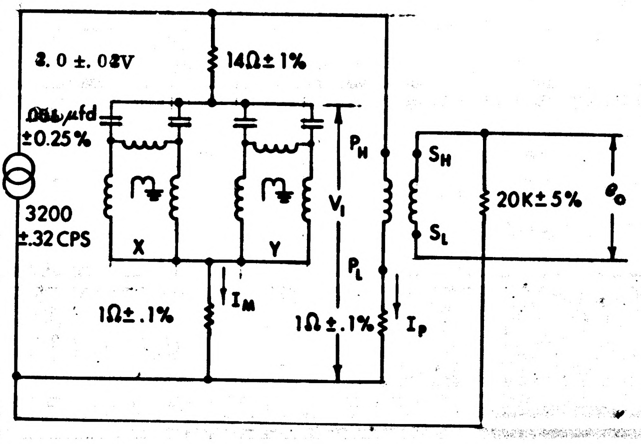
SHEET 2
OF 2

3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.


3.0 ±.08V
14Ω± 1%
.051 μfd
±0.25%
3200
±.32 CPS
X
Y
P_H
V_1
P_L
S_H
S_L
20K±5%
e_o
1Ω±.1%
I_M
1Ω ±.1%
I_p

No connections shall be made to quadrature or denter tap tap terminals.

Fig. 1

APOLLO II IRIG Specification
MC 25-859
Release Date Nov. 25, 1964
Release Revision A
Class A **Release**
TDRR 14531

Procedure for Testing
SG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	 NASA
2/12/65	B	16568	1, 2	WK	JBM 2/17/65
3/18/65	C	17645	1, 2	WK	WJR
6/8/65	D	20017	1	WK.	JBM

This MC specification consists of page i and 1 to 2 inclusive.

TP# 11938

Rev D 6/3/65
Rev. C 3/18/65
Rev. B 2/12/65
Rev. A 11/9/64

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5%F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Fig. 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

DB 2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1° and I_m = 43.5 ± 3 ma.

A B 2.5 Disable SG primary and measure suspension reaction torque. Record. Limit is 0 ± 0.15 dyne-cm.

3.0 Signal Generator

B 3.1 Reconnect per Fig. 1. Disable suspension, and increase V_{in} to 4.0 v.

A 3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating and recording the angular sensitivity and relative phase of E_o vs V_{in}.

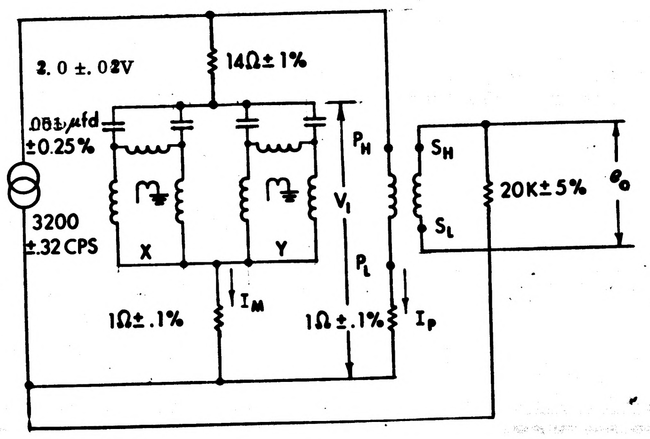
3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.

A

B

C



No connections shall be made to quadrature or center tap tap terminals.

Fig. 1

APOLLO II IRIG Specification
MC 25-860
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Duplicate Master to replace original, destroyed in reproduction. 8 June 1965 W.S.K. MIT/IL

. Procedure for Testing
TG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/2/65	B	16570	1 & 3	WK.	JSM
3/18/65	C	17646	1, 3	WK.	WJR
6/8/65	D	20018	1	WK	JGM

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This MC specification consists of page 1 ~~to~~ ___ and 1 to 3 inclusive.

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PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964 MC 25-860
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Rev. A 11/9/64 Rev B 2/2/65 Rev C 3/18/65 Rev D 6/3/65

PROCEDURE FOR TESTING TG END HOUSING ASSEMBLY
APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture device DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5% F during testing.

A 1.3 Rotor ID run-out torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 2.1 Connect and excite the assembly per Fig. 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating for minimum E_o.

DB 2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1°. and I_m = 43.5 ± 3 ma.

A B 2.5 Disable T_{comm}. Measure and record suspension reaction torque. (0 ± 0.15 dyne-cm)

3.0 Torque Generator

3.1 Reconnect per Fig. 2 and adjust for null.

3.2 Connect and excite per Fig. 3A and measure current-squared squared torque sensitivity.

3.3 Repeat per 3B. If + and — torque sensitivities are not equal, dummy direct torque summing member to a new angle. Cneck + and — sensitivities until they are equal within 1%. Record sensitivities. During this test, check radial centering, but disable suspension while torque measurements are being made.

3.4 Reconnect per Fig. 2.

3.5 Measure and record magnitude and relative phase of E_o at the angle found in 3.3. This information will be used in Dry Centering Procedure MC 25-854.

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PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964 MC 25-860
SHEET 2 OF 3

3.6 Place an indexing mark on the + or — IA axis of the rotor. This information is used in Final Assembly Procedure MC 25-853, step 2.A.5.

A 4.0 Bias Winding

4.1 Disable suspension and TG, zero all airbearing torque.

4.2 Measure and record the torque sensitivity of the bias winding. Connect reset coil and bias winding in series. Excite with 20 and 40 ma at 3200 cps. Average and record the torque sensitivity. Do not exceed 100 ma.

5.0 Residual Torque Test

5.1 Use residual torque testing electronics dwg #D128144.

5.2 Disable suspension and TG. Zero out all air bearing torques.

5.3 Apply 3 pulses to T+ winding. Read torque.

5.4 Apply 3 pulses to T- winding. Read torque. Calculate the difference in torque readings. Record.

5.5 Apply 50 ma at 3200 cps to the reset winding and repeat 5.3 and 5.4. Record Δ torque.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
PREPARED BY: G. Garcia
J. Aronson MC# 25-860
DATE: February 25, 1964
SHEET 3 OF 3

CB

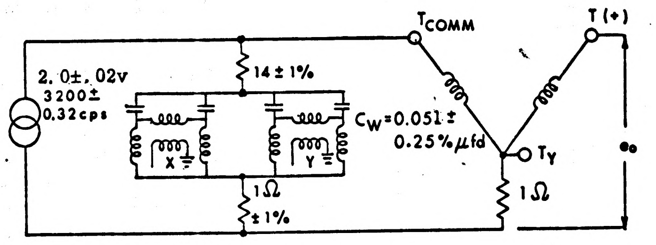


Fig. 1

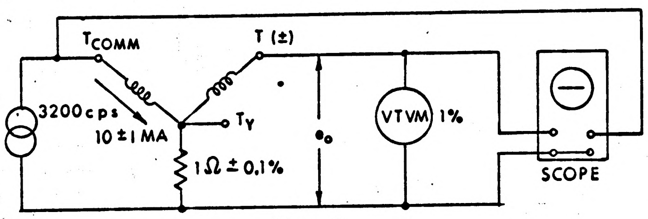


Fig. 2

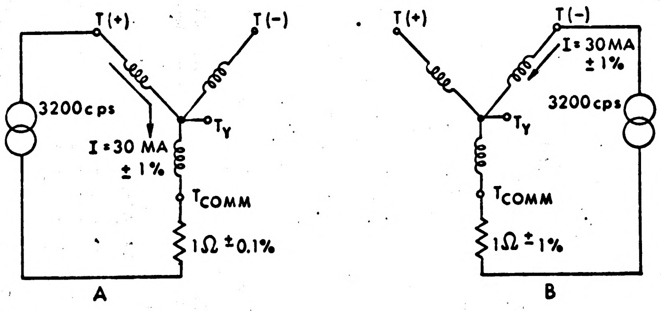


Fig. 3

sheet (M.C. 25-886), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

4.2 Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

4.3 If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator should not exceed 20 microinches, and should not extend more than .040" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

4.4 Record the actual finished bore size on the wheel assembly data sheet (M.C. 25-886).

4.5 Clean inertia element assembly 3 minutes in varsol and 3 minutes in Freon in ultrasonic cleaner. Vacuum dry after each solution.

4.6 Place the inertia element assembly in a vacuum oven at 150°±5° and evacuate for one hour at full vacuum.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
  Model 153-40 used with small jet spindles and Class XXX
  Master Gage Rings
Hand Lap-3/8" dia. x 3" long-American Lap Co.
Lapping Compound 38-1200-U.S. Products Co.
Oliver oil or
Mobil Velocite E oil-Socony Mobil Oil Co., Inc.
Zeiss Stereo Microscope
Vacuum Oven-Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner.

5.0 NUMBERING WHEEL (If Inertia Rim not previously numbered)

5.1 Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).
Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

5.2 Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e.g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries Inc.,
  Sycamore, Illinois

6.0 B DIMENSION MEASUREMENT (Dimension Over The Hub)

6.1 Using a 0.975999 gage block and the Johansson Mikrokator S 510- E-8, measure accurately (to within 5 microinches) dimension B and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mikrokator reference block.

Equipment

C.E. Johansson Mikrokator S510E-8
Gage blocks

7.0 CONTACT ANGLE MEASUREMENT BY INNER RACE ROTATION (Refer to Para. 1.4)

7.1 Clean bearing assemblies per MC 25-878.

7.2 Assemble outer races as in paragraph 13 of this specification. For this measurement tapered or stepped pocket retainers can be used, insure that interference is reduced to a minimum by predenting the ball pockets, eliminating possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this

---

measurement, these retainers must not be used in the final bearing assembly.

7.3 Install the shaft and the mating outer race fixture D-95850 and rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

7.4 Determine the contact angle using the following formula:

$$\mathrm{Cos}\,\beta = \frac{E}{d}\left[1 - 2\,\frac{N_e}{N_i}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
N_i = number of inner race revolutions
N_e = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

7.5 Record data on MC 25-886.

Equipment

Contact Angle Gage (D-95850)

8.0 PRELOAD SPACER THICKNESS SELECTION

8.1 With dimension A as recorded on bearing package by manufacturer, and dimension B as measured in section 6, determine spacer thickness by using the following formula:
A = B + t-65 microinches
or t = A - B + 65 microinches
where t is the spacer thickness and the 65 microinches shaft stretch as explained in section 14.

9.0 NYLASINT RETAINER PROCESSING

9.1 NYLASINT RETAINER IMPREGNATION

9.1.1 Ultrasonically clean retainers in distilled water for three-five ±1/2 minute periods (change water after each period). Vacuum dry after each five minute period.

9.1.2 Ultrasonically clean retainers in freon for five ± 1/2 minutes.

9.1.3 Vacuum bake retainers for two hours minimum at 130° - 150°F and 29.5" HG vacuum minimum.

9.1.4 Remove retainers one at a time from the oven and weigh immediately. Record weights and corresponding retainer numbers.

9.1.5 Suspend retainers over a beaker of filtered V-78 oil in 150°-160°F oven and evacuate to 29.5" Hg vacuum minimum until bubbling stops. Drop retainers in oil and maintain vacuum for 4 hours minimum. Vent and keep retainers in oil for an additional 4 hours minimum.

9.2 NYLASINT RETAINER CENTRIFUGE

9.2.1 Centrifuge retainer for 15 ± 1 minute at 9000 ± 150 G's one side only.

9.2.2 Remove from centrifuge and blot retainer edges with lens tissue.

9.2.3 Vacuum bake retainers for two hours minimum at 150°-160°F and 29.5" Hg vacuum minimum.

9.2.4 Remove retainers from oven and weigh immediately.

9.2.5 Compute oil retention of each retainer as follows:

$$\%\ \text{retention} = \frac{W_1 - W_0}{W_0} \times 100$$

where W_0 = weight of dry retainer
W_1 = weight of retainer after impregnation

Acceptable oil retention values are in range of 14.5% to 17.0%.

If oil retention is above 17.0% repeat above centrifuge procedure.

9.2.6 Store retainers in a covered pyrex dish using dessicants to minimize the humidity of the storage environment.

9.2.7 General Notes:

9.2.7.1 Retainers should be handled with either tweezers or gloves to minimize moisture absorption and contamination.

9.2.7.2 When not actually being worked on, the material and/or retainers should be stored as in 9.2.6 above.

9.2.7.3 The only solvents to be used with nylasint are freon, reagent grade benzene, and distilled water.

9.3 Equipment

9.3.1 International centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts, or equivalent.

APOLLO II IRIG Specification
MC 25-507
Release Date Nov. 18, 1964
Release Revision A
Class A Release
TDRR 14363

Microsyn Potting

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/12/65	B	16569	1, 2 & 3	WR	2/17/65

TP#11938

This MC specification consists of page 1 ~~to~~ ___ and 1 to 3 inclusive.

I. Microsyn Potting

B 11. Insert the forming gasket (A-112983), the inlet pipe (A-122133), and the outlet pipe (A-110488) into the top mold plate (B-112982). The inlet and outlet pipes should be 1/64 below flush in the mold.

2. Insert the two fill hole plugs (A-113298) into the end housing from the bellows side. Using depth micrometers, measure the depth from the edge of the end housing down to the inner end of the teflon plugs. This depth is .420" max. Remove the plugs and trim if necessary.

B A 3. Using an artist's brush, coat the O.D. of the end housing and the O.D. of the bottom mold plate with DC-20 or RAM 225 release. Wipe off excess with a "Kimwipe."

4. Assemble the end housing to the top plate, lining up the buttons and orifices. Reinsert the two fill hole plugs. Assemble the bottom plate.

5. Holding the mold assembly together, position teflon gasket A-110491 on the bottom mold plate, then slide inner housing B-115779 down over the outlet pipe and pick up the guide pin.

6. Tip the outer housing C-110736 at a comforable angle and insert mold-inner housing assembly positioning the piston bore next to the thermoswitch.

Rev. A 9/2/64

7. Place potting mold upright.

8. Assemble top coverplate.

9. Assemble teflon gasket and outlet orifice to inner housing.

10. Assemble piston assembly onto mold. Adjust yoke screws so that piston "0" ring just enters inner housing bore.

B A 11. Weigh out 90 grams (min.) of P-14 compound (SCD 2021535). Rubber gloves should be worn during all handling of compound and activator. Place in oven and heat to 212°F until fluid, approximately 45 minutes.

B 12. Connect the mold to 110 volts. (Allow to heat at same time as compound.)

13. Connect overflow assembly (1 oz. jar, stopper) to potting mold.

14. Check tightness of mold by pulling vacuum down to 3000 microns.

B 15. Weigh out 2.8 grams of activator (BA+1) [illegible]. (32.2 to 1 of P-14 compound to activator).

B 16. Remove compound from oven and add activator. Mix very thoroughly with stirring rod under ventilation hood for one minute. (Fumes generated are toxic.) Then place in vacuum oven until initial frothing disappears - approx. 1 to 2 minutes.

17. Remove piston assembly from mold and pour in compound. Replace piston.

B 18. Connect overflow jar to vacuum pump. [illegible]

B 19. Turn mold upside down on fixture, and open vacuum valve.

B 20. Degas 1 to 2 minutes, until vacuum levels out at about 1000 microns.

21. Return mold to right-side-up position. Continue degassing.

22. Take up on yoke screws slowly, allowing the piston to force the compound into the end housing and into the overflow jar. (Use two Spintite wrenches.)

B 23. Continue degassing compound as it enters overflow jar for approximately 30 seconds. Stop vacuum pump and release vacuum.

24. Take up another turn or two on the yoke screws.

25. Remove overflow assembly from outlet orifice. Quickly screw outlet orifice cap in place, pull down snugly.

26. Take up on yoke screws until loading spring is compressed to its solid height.

B A 27. Allow to cure at least four hours at 212°F or 160° ±8°F and at a pressure of 270 ±20psia. (Thermoswitch setting in mold.)

28. Discard overflow jar and mixing container.

29. Clean copper fittings. (Blow out potting compound from copper tubes with an air hose.) Store in a jar of Cobehn solvent.

30. After curing, disassemble mold carefully.

31. Clean all parts of mold and store. Do not use solvents on teflon coated mold parts.

B 32. Make resistance measurements and check insulation resistance using a 250 v dc megohmmeter. Record on MC 25-858.

APOLLO II IRIG Specification
MC 25-707
Release Date Nov. 4, 1964
Release Revision A
Class A Release
TDRR 14046

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
1/18/65	B	15626	1	WK.	WJR

This MC specification consists of page 1 to - and 1 to 7 inclusive.

TP#11938

APOLLO II

B

1. Design Specifications (Preliminary)

A. Gyroscopic Element

1. Drive Stator

a. Type: Synchronous Hysteresis
b. Number of Poles: 4
c. Number of Phases: 2
d. Phase Rotation: A to B
e. Frequency: 800 cps
f. Angular Speed: 24,000 rpm

B

	At Start	At Synchronism
g. Impedance (Z):	128 + j942	115 + j164
h. Voltage (V):	28 volts	28 volts
i. Current (I):	176 ma	140 ma
j. Power (W):	7.9 watts	4.5 watts
k. Torque (T):	10,000 d-cm	7,000 d-cm

Rev. B 1/18/65
Rev. A 6/29/64

2. Wheel

a. Type of bearing Construction: Angular Contact Duplex DF Mounted with Adjustable Preload and Isoelasticity Capability.

b. Contact Angle: 31° ±1/2° at no load.
Contact Angle: 31 1/2° ±1/2° at 3 lb. load.

c. Inner Race Curvature: 54.0%.
Outer Race Curvature: 57.5%.

d. Breakaway Torque: Approximately 2000-2500 d-cm.

e. Running Torque at Operating Temperature: 600-1500 d-cm.

f. Windage Torque in Air: Approximately 3000 d-cm.

g. Preload: 2-4 lb.

---

h. Maximum Stress Inner Race: 208,000 psi.
Mean Stress Inner Race: 138,000 psi.

i. Axial Compliance at Operating Temperature:
9-12 microinches/lb.

Radial Compliance at Operating Temperature:
9-12 microinches/lb.

j. Bearing Run-in Time: 200 hrs.

k. Anisoelastic Torque Due to Bearing Compliance Difference (C = .75 microinches/lb. Max.): .017 d-cm/g^2.

l. Weight of Rotating Wheel Parts: 83.7 grams.

m. Moment of Inertia of Rotating Wheel Parts: 173 gram-cm^2

n. Angular Momentum at 24,000 rpm (H): .434 X 10^6 gram-cm^2/sec.

o. Time to Synchronous Speed at 28 volts in float: 90 sec. max.

p. Coast Down Time in Float to 6000 rpm: 130 sec. nominal.

B. Float Assembly

1. Size: 1.980 inch sphere.

2. Weight 184.0 grams.

3. Moment of Inertia:
About OA: 367.3 gram-cm^2
About IA: 650.8 gram-cm^2
About SRA: 724.9 gram-cm^2

4. OA Angular Freedom: 24 mr.
Minimum Angular Rotation From S.G. Null: 10 mr.

5. T.G. Null Alignment with Respect to S.G. Null: ± 1/2 mr.

6. Distance Between Suspension Rotor Centers: 2.48 inches.

---

7. Float Balance Range: 0 to 25 d-cm.

8. Float Balance Resolution: .070 d-cm (5° on balance adjustment).

C. Damper

1. Type: Brominated Fluorocarbon

2. Fluid Designation: 2400/137/2.385

3. Viscosity: 2400 centipoise at 137°F.
Viscosity Gradient: 42.2 centipoise/°F.

4. Density: 2.3850 grams/cc at 137°F.
Density Gradient: 10 X 10^{-4} grams/cc/°F.

5. Fluid Volume Gradient: 4.0 X 10^{-4} cc/cc/°F at 137°F.

6. Maximum Bellows Temperature Compensation: 180°F range.

7. Fluid Internal Pressure: 34 psi at 137°F.

A

8. Damping Coefficient
About OA: 4.75 X 10^5 d-cm/rad/sec.
About IA: 1.5 X 10^9 d-cm/rad/sec.
About SRA: 1.5 X 10^9 d-cm/rad/sec.

D. Signal Generator

1. Type: 12 MY-1.75-20A E-Connected Microsyn with 8-pole rotor.

2. Frequency: 3200 cps.

3. Input current: 17 ma

4. Input voltage: 4.0 volts

5. Maximum input current: 150 ma.

6. Null output voltage: 0.5 mv. compensated.

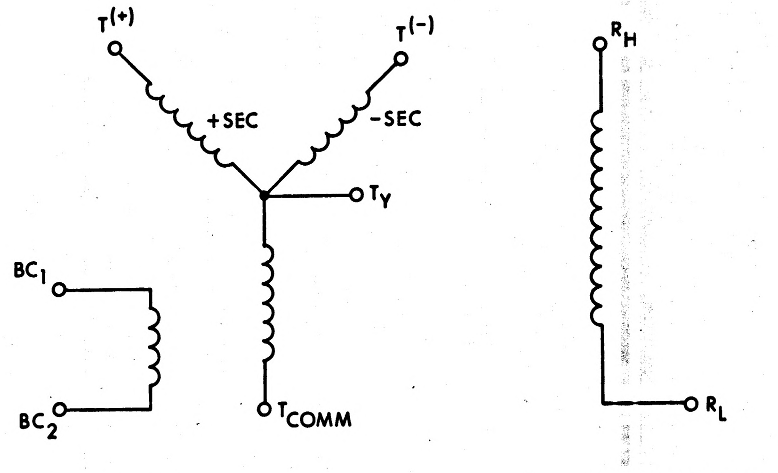
7. Sensitivity: 10 MV/MR

8. Air gap: .010 inch.

		Primary	Secondary
9.	Turns per coil:	200	200
10.	Wire Size:	#35	#35 AWG
11.	D.C. Resistance at 135°F:	23 ohms	46 ohms
12.	Impedance (3200 cps):	30 +j230 ohms	57 + j535 ohms
13.	Reaction torque:	.05 dyne-cm max.	
14.	Angular Elastic Restraint:	.025 dyne-cm	

E. Torque Generator

1. Type: 12 MY-1.75-21A Pulse Torqued, modified E-connection with residual reset winding, and bias compensation winding.



BIAS COMPENSATOR

RESET WINDING

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2. Maximum input current: 130 ma.
3. Torque Sensitivity: $T^{(+)}$ or $T^{(-)}$ to T_{comm} = .6 dyne-cm/ma^2
4. Air gap: .010 inch.

		Primary	Torquing Winding T(+)	Torquing Winding T(-)
5.	Turns per coil:	400	200	200
6.	Wire size:	#38 AWG	#38 AWG	
7.	D.C. Resistance at 135°F:	92 ohms	92 ohms	92 ohms
8.	Inductance:	47 mh.	27 mh.	

9. Reset Winding: Impedance at 3200 cps 61 + j67 ohms
Max. input current 80 ma.
Residual magnetic torque
.01 dyne-cm. max at 45 ma, 3200 cps.

10. Bias Compensation Winding: 6 turns #38 AWG on pole #9
DC Resistance .6 ohms
Torque sensitivity with reset winding 5.8 X 10^{-4} dc/ma^2

F. Magnetic Suspension

1. Type: T.I.S. - .750 - 4A - Tapered 20° included angle.
2. Frequency: 3200 cps.
3. Input Voltage: 4.0 V.
4. Current: 83 ma.
5. Damping Resistor: 7.0 ohms per gyro.
6. Working Capacitor: 0.055 ufd. nominal.
7. Air Gap: .003 inch
8. Impedance/coil pair: 106 + j1020 ohms

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9. Winding: 2.5 Turns/coil #40 AWG
10. Radial Stiffness: 6 gm/.0001" Radial
0.8 gm/.0001" Axial

G. Temperature Sensor

1. Type: Thermistor
2. Number/Gyro: 2
3. Location in Unit: One in each End Housing suspended in fluid.
4. Nominal D.C. Resistance at 135°F: 345 ohms/one.
5. Operating Temperature: 135°F ±2°F at the Thermistors.
Damping Gap Temperature: 137°F ±2°F.
6. Temperature Gradient: 6 ohms/°F/Thermistor.
7. Stability: 1%.

H. Shroud Jacket

1. Functions:
   a) Provides Magnetic Shielding
   b) Provides a Vacuum Envelope for the Gyro.
2. Material: Mu Metal Main Cover, Stainless Steel End Covers.

A I. Gyro Constants

1. Time Constant ($\frac{I_{OA}}{C_{OA}}$): 770 microseconds.
2. Angle In - Angle Out Sensitivity at 24,000 rpm ($\frac{H}{C_{OA}}$): .942
3. Angle In - Voltage Out Sensitivity at 24,000 rpm
($\frac{H}{C}$ X S_{SG}): 9.4 mv/mr.
A 4. Angular Momentum at 24,000 rpm (H): .434 X 10^6 gm-cm^2/sec.
5. Damping Coefficient (C_{OA}): 475,000 d-cm/rad/sec.
6. Float Output Axis Inertia (I_{OA}): 367.3 gm-cm^2.

A 7. Signal Generator Sensitivity (S_{SG}): 10 mv/mr.

8. Gyro Pulse Scale Factor: $\frac{\pi}{2^{20}}$ rad/pulse at 3200 pps

J. Mechanical Characteristics

A 1. Without Shroud
   a) Size: 2.38 dia. X 3.680 in. long.
   b) Weight: 1.3 lb.
   c) Mounting: End Mounted
   d) Electrical Connections: 16 pins/end.

2. With Shroud
   A a) Size: 2.42 in. dia. X 3.750 in. long.
   b) Weight: 1.55 lbs.
   c) Mounting: End Mounted.
   d) Electrical Connections: 16 pins/end.

3. Prealigned
   a) Size: 2.810 dia. X 5.10 in. long.
   b) Weight: 1.97 lbs.
   c) Mounting: End Mounted.
   d) Electrical Connections: 26 pin continental connector.

APOLLO II IRIG Specification
MC 25-852
Release Date Jan 5, 1965
Release Revision A
Class A Release
TDRR 15323

Assembly of Shroud to Gyro Unit

Date	Revision Letter	TDRR No.	Pages Revised	Approval	
				MIT	NASA

TP#11938

This MC specification consists of page 1 to ___ and 1 to 5 inclusive.

Rev. A 11/20/64
Revised and Rewritten

ASSEMBLY OF SHROUD TO GYRO UNIT, APOLLO II

SHROUD END COVER ASSEMBLY

Equipment Required

450 Watt Hot Plate
60 Watt Soldering iron Pyramid Tip
Variac
Solder - 96.5 Tin; 3.5 Silver
Solder - 60 Tin; 40 Lead
Flux Kester 891 - Kester 1571
Artist Brush #3 - Acid Brushes

1. End Cover Preparation
   - A. Clean the end cover ultrasonically in trichlorethylene, followed by freon rinse.
   - B. Leak check end cover for porosity using fixture 2A-10B182.0.
2. Tinning Procedure
   - A. Place the end cover on hot plate and heat to 250°F. ± 10°.
   - B. With an artist brush apply 891 Kester flux to the outside area of the 17 holes.
   - C. Generously tin with 96.5 Sn-3.5 Ag solder around and in the holes, supplying additional heat with the soldering iron.
   - D. Repeat steps B and C on inside of cover.
   - E. Remove from hot plate and allow to cool.
   - F. Tin the 2.443 diameter of the end cover using 60-40 solder and Kester 891 flux.
3. Cleaning Procedure
   - A. With an acid brush scrub the end cover using trichloroethylene or some other suitable solvent.
   - B. Follow by scrubbing under running hot water using Ajax, powdered Boraxo or equivalent.
   - C. Thoroughly rinse under running hot water and dry.

---

4. Assembly of Seals to End Covers
   - A. Tin degassing plug (2021616) with 96.5 SN 3.5 Ag solder and Kester 891 flux. A
   - B. Refer to step #3 for cleaning.
   - C. Place end cover on hot plate and heat to 490°F x ± 10°F.
   - D. Apply 1571 flux to tinned area.
   - E. Flux the .125 diameter on the (16) terminal seals (2021508) and the degassing plug (2021616) with 1571 flux and insert into position. A
   - F. When the solder begins to flow, carefully apply additional 1571 flux around all the seals.
   - G. Carefully remove from the hot plate and allow to cool.
   - H. Repeat cleaning procedure #3.
   - I. Polish the end covers using 305A lapping compound, followed by 38-1200 compound. Final clean as in step #3.
   - J. Seal the degassing plug hole with the aluminum ball and seal screw. Leak check using fixture B-130412. If the leak rate is greater than the minimum detectable leak rate of the MS-9 2×10^{-10} atm-cc/sec. the assembly should be rejected.
   - K. Hi Pot - 250 volts (DC).
5. Main Cover Preparation
   - A. Degrease in trichloroethylene, followed by freon rinse.
   - B. Tin the 2.440 diameter and two .010 deep relief with 60-40 Solder and Kester 891 flux.
   - C. Refer to step #3 for cleaning.
6. Insert Preparation
   - A. Degrease in trichloroethylene, followed by freon rinse.
   - B. Tin concave side with 60-40 solder and 891 Kester flux.
   - C. Refer to step #3 for cleaning.
7. Internal Connector Assembly
   - A. Check the connector assembly for shorts or opens.

- B. Assemble the connector into the end cover sub-assembly by individually soldering each lead into respective holes: Use 96.5 SN-3.5 Ag solder and 1571 flux. This is conveniently done by tinning a small iron (similar to the one used for flex lead installation) with 96.5 SN-3.5 Ag solder and allowing the solder to flow down the wire into the hole.
- C. Carefully clean all joints with trichlorethylene, and artist brush, followed by a freon rinse.
- D. Perform an electrical check of this assembly, checking for grounds, shorts, and opens. Hi pot at 250 volts.
- E. Apply LCA-9 adhesive (MC 25-302) over the glass seals and any exposed wires.
- F. Form the wires carefully at terminal to provide a 180° bend strain relief.
- G. With lacing cord make two ties in each pair of six leads about one inch apart.
- H. Make a final electrical check on assembly.
- I. Leak check assembly as in J of step #4.
- J. Degauss shroud parts. Check for magnetic poles using small watchmaker's compass. (MC 25-401)

8. Assembly of Shroud Parts to Gyro Unit
   - A. Stablize fixture C-130409 at 140°F. $^{+0^\circ}_{-5^\circ}$ prior to removing unit from storage oven.
   - B. Select the adapter A-130410 which will center the main cover on the gyro unit.
   - C. Place the adapter on the gyro and mount in the thermally stabilized well with the signal generator end up.
   - D. The fit of the main cover to the unit should be line on line to .0004 loose.
   - E. Carefully inspect the OD of the unit for burrs or excess cement which would interfere with assembly of main cover to the gyro.

PREPARED BY: Robert A. Booth
DATE: February 24, 1964
MC 25-852
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OF 5

F. Align the open ports in the main cover with the + SRA and + IA gyro axis and slide the main cover all the way down until it seats on the adapter A-130410.

G. Install the end cover assembly on the unit carefully mounting each terminal connector on the end housing pins. Position the cover onto the end housing taper. Inspect to make sure there is no rocking.

H. Perform an electrical check for correct resistances, opens and grounds.

I. Apply a minimum amount of 1571 Kester flux to main cover - end cover joint with a piece of solder.

J. Use a 60 Watt iron and 60-40 solder to make the joint while the guide post is slowly rotated by hand.

K. Place the well in a horizontal position on fixture and re-flux joint with 1571 Kester flux. Complete soldering joint making sure that the gap is completely filled.

L. Excess solder can be cleaned off using a sharp edge dental tool and a hard rubber abrasive eraser.

M. Raise the guide post and invert the instrument in the fixture at the same time removing the adapter A-130410.

N. Install the second cover assembly as before.

O. Unit is ready for preliminary testing.

A 9. Final Shroud Seal

A. Apply minimum amount of 1571 Kester flux to the two .010 deep reliefs on the main cover and concave surface of the inserts.

B. Position insert on main cover so as to follow general contour of 2.460 dia.

C. Using a soldering iron and 60-40 solder make the insert - main cover joint and remove excess solder.

NOTE: A vee block or similar fixture maintained at $140^{+0^\circ}_{-6^\circ}$ F. may be used.

PREPARED BY:
DATE:
SHEET 5
OF 5

A 10. Leak Check of Shrouded Unit

Stabilize leak check fixture C-127683 at $140^{+0^\circ}_{-5^\circ}$ prior to positioning unit.

With a very small amount of vacuum grease, tack the 1/16 diameter aluminum ball (17S-T4) to the 2-56 x 3/32 long S.S. set screw. Attach the ball and screw to the multispline wrench in fixture C-127683.

Leak check one end of the assembly at a time. Do this by sealing off the degassing plug on the exposed end of the unit and spray the terminals, ports and main seam at the end with helium or argon. The degassing hole on the opposite end is left open. The maximum acceptable leak rate is 1×10^{-8} ATM-cc/sec.

Before inverting the unit to leak check the other end, the first degassing seal will have to be opened up again. The deformed ball seal can be removed with a small screwdriver.

Final Seal as a Hermetic Assembly

While still on the leak check fixture and with 10-50 microns as the indicated vacuum in the shroud, run the aluminum ball and set screw into the degassing plug.

Store in a $140^\circ {}^{+0^\circ}_{-5^\circ}$ oven awaiting final testing prior to delivery.

11. Continue with prealignment per MC 25-847.

APOLLO II IRIG Specification
MC 25-860
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Procedure for Testing
TG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/2/65	B	16570	1 & 3	WK.	JBM

This MC specification consists of page 1 ~~to~~ ___ and 1 to 3 inclusive.

TP#11938

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.
PREPARED BY: G. Garcia
J. Aronson
DATE: February 25, 1964

MC 25-860

Rev. A 11/9/64 Rev B 2/2/65

PROCEDURE FOR TESTING TG END HOUSING ASSEMBLY

APOLLO II IRIG

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture device DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5% F during testing.

A 1.3 Rotor ID run-out torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 2.1 Connect and excite the assembly per Fig. 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

B 2.3 Center microsyn angularly by rotating for minimum E_o.

2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1°. and I_m = 42.5 ± 3ma.

A B 2.5 Disable T_{comm}. Measure and record suspension reaction torque. (0 ± 0.15 dyne-cm)

3.0 Torque Generator

3.1 Reconnect per Fig. 2 and adjust for null.

3.2 Connect and excite per Fig. 3A and measure current-squared squared torque sensitivity.

3.3 Repeat per 3B. If + and — torque sensitivities are not equal, dummy direct torque summing member to a new angle. Check + and — sensitivities until they are equal within 1%. Record sensitivities. During this test, check radial centering, but disable suspension while torque measurements are being made.

3.4 Reconnect per Fig. 2.

3.5 Measure and record magnitude and relative phase of E_o at the angle found in 3.3. This information will be used in Dry Centering Procedure MC 25-854.

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DATE: February 25, 1964

MC 25-860

3.6 Place an indexing mark on the + or — IA axis of the rotor. This information is used in Final Assembly Procedure MC 25-853, step 2.A.5.

A 4.0 Bias Winding

4.1 Disable suspension and TG, zero all airbearing torque.

4.2 Measure and record the torque sensitivity of the bias winding. Connect reset coil and bias winding in series. Excite with 20 and 40 ma at 3200 cps. Average and record the torque sensitivity. Do not exceed 100 ma.

5.0 Residual Torque Test

5.1 Use residual torque testing electronics dwg #D128144.

5.2 Disable suspension and TG. Zero out all air bearing torques.

5.3 Apply 3 pulses to T+ winding. Read torque.

5.4 Apply 3 pulses to T- winding. Read torque. Calculate the difference in torque readings. Record.

5.5 Apply 50 ma at 3200 cps to the reset winding and repeat 5.3 and 5.4. Record Δ torque.

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B

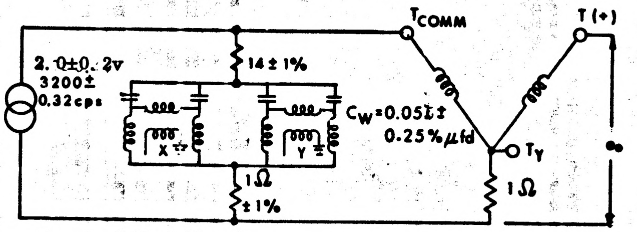

Fig. 1

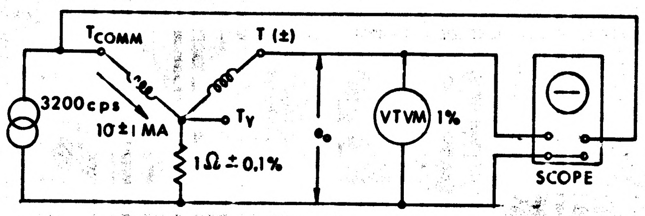

Fig. 2

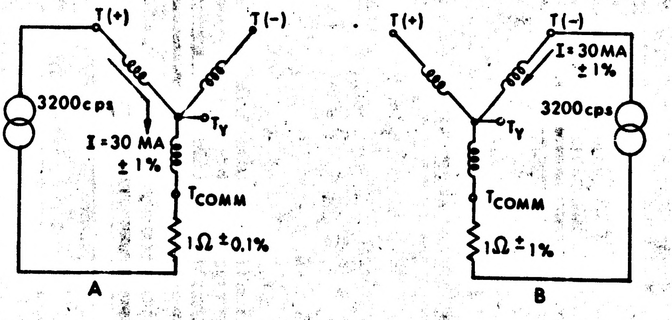

Fig. 3

APOLLO II IRIG Specification
MC 25-857
Release Date Nov. 25, 1964
Release Revision A
Class A Release
TDRR 14531

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	NASA
1-18-64	B	15625	1, 5	WK.	WgR

This MC specification consists of page i to ~ and 1 to 5 inclusive.

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CAMBRIDGE, MASS.

PREPARED BY: David N. Kupelian
DATE: September 18, 1964

MC 25-857

SHEET 1 OF 5

Rev A 9-21-64
Rev B 1-18-65

A. ~~END HOUSING ASSE~~ END HOUSING ASSEMBLY, APOLLO II IRIG

I. Terminal Seal Assembly

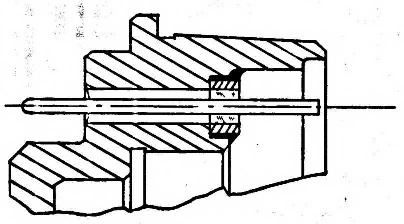
1. Clean the end housing and terminal seal ultrasonically in trichloroethylene, followed by a freon rinse.

A. 2. Leak check terminal seal using fixture B-123696 max leak rate 0.10×10^{-8} ATM-cc/sec. Leak rate ________

3. Place the end housing in the end housing holding fixture. ~~Leak rate~~

4. Place this assembly on a thermostatically controlled hot plate and heat the end housing to 160°F ±10°F for approximately ten (10) minutes.

5. With a watchmaker's spade oiler or some other suitable applicator, apply LCA-9 (MC 25-302) to the end housing as shown below.



A. 6. Insert the terminal seal into the end housing.

7. Press the terminal seal into position with a small piece of sharpened pegwood to force the adhesive around the terminal and into the sixteen (16) 0.070" diameter holes in the end housing.

8. Center the terminal seal in the end housing using fixture C-127580.

9. Place the end housing holder and end housing in a 200°F oven and cure for two (2) hours.

10. After the initial two (2) hour cure, remove the assembly from the oven and cool to room temperature. As the 0.070" diameter holes are too deep to be completely filled with the adhesive, it is necessary to back-fill the pins. Feed C-7 adhesive into the holes and around the pins carefully. The adhesive should be flush or below flush with the bottom of the chamfer on the 0.070" diameter hole.

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11. Repeat Step #9

12. Assemble the end housing to the leak check fixture A-87326 and leak check. If the leak rate is greater than 2×10^{-10} ATM-cc/sec; the assembly should be rejected.

13. Cycle the assembly from 0°F to + 180°F four times at a maximum rate of 3°/min.

14. Repeat Step #12.

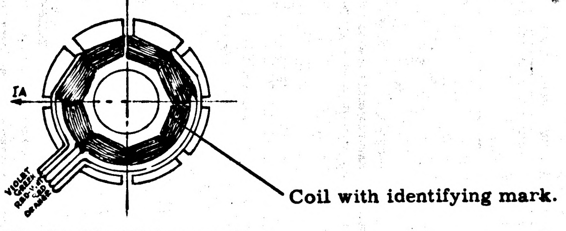
15. Mix 25 grams of Silastic RTV (Dow Corning) with 1.0 gram of Activator #881 and mix thoroughly. Coat the body of the terminal seal assembly and cure at 160°F for two (2) hours.

A II. Assembly of Inner Suspension to End Housing

1. Visually inspect the inner suspension 2021657 paying particular attention to solder connections and any loose wires that could be damaged during potting and grinding operations.

2. Perform resistance measurements and record the requested information on MC 25-858.

A 3. Shape and group the wires of the suspension as shown in the sketch below.



A 4. Apply LCA-9 adhesive to the suspension seating shoulder of the end housing.

A 5. Assemble the inner suspension to the end housing, aligning the registration mark along the IA axis using fixture A-113109. See sketch below.

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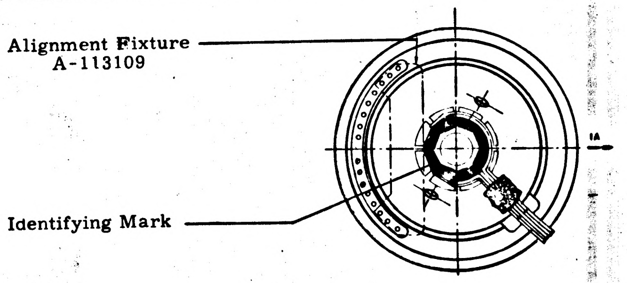
A



6. Cure as per MC 25-302

7. Group the five (5) suspension wires as shown in the sketch of Note 5 and hold them in position with positioning fixture A-113235.

8. Bond the wires to the floor of the end housing using LCA-9 adhesive (See MC 25-302). Do not apply a heavy layer of adhesive over the wires. The outline of the wires should be just visible through the adhesive (0.035 max adhesive build-up). Cure the adhesive.

III. Assembly of the Microsyn to the End Housing

1. Perform a resistance check of the microsyn, and record on MC 25-858.

2. Check the microsyn for loose wires, loose or cold solder connections, solder build-up, burrs or cement build-up on the O.D. or windings.

3. Carefully fit the microsyn into the end housings aligning the 16 holes in the microsyn printed circuit with the pins and feeding the inner suspension wires through the slot in the printed circuit. Be sure the microsyn is seated. Perform an electrical check.

A 4. Solder the 7 short pins to the printed circuit using 60-40 solder and Kester 1571 flux. Carefully clean the solder joints with Kesters AP-20 or with an artists brush dipped in trichloretnylene and rinse with freon. Perform a resistance measurement and record.

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IV. Assembly of Printed Circuit and Mumetal Shield

A 1. To insure solderability, remove surface film on buttons 2021655 either chemically or mechanically.

A 2. Tin both sides of the pads of printed circuit 2021652 (around the 0.062" diameter plated through holes). Clean with an artist's brush dipped in trichloroethylene and rinse with freon.

3. Apply a small amount of Kester 1571 flux to shoulder of the button. Position the buttons in the printed circuit and using a 37 1/2 watt iron, apply heat to the top of the button in order to form a solder fillet at the base. Clean as in step 2.

4. Cement the mumetal shield to the back of the printed circuit with Epon 828 adhesive and assemble to bonding fixture B-87377. Cure for 1 1/2 hours at 150°F.

5. Any excess adhesive on the O.D. of the assembly can be removed by using a medium grit emery paper. Rinse in freon.

V. Assembly of Printed Circuit to End Housing

1. Apply three tacks, at 120° intervals, of LCA-9 or Epon 828 adhesive to the end housing mounting shoulder.

2. Assemble the printed circuit to the end housing by feeding the 5 inner suspension wires through the slot and aligning the nine terminal pins with the holes of the printed circuit.

3. Solder the (9) terminal pins with 60-40 solder and Kester 1571 flux. Clean as in Section IV, 2.

   NOTE: The height of all solder joints should be kept to a minimum to insure complete coverage during the potting operation.

4. Cut the (5) inner suspension wires so that the end of the wire will not reach the far end of the printed circuit pad. Strip the wire back as far as the slot in the printed circuit. Flare and flatten the wire strands and solder the wires to the printed circuit.

   NOTE: Keep height of the bend of the wire and the 5 solder joints at a minimum. Clean as in Section IV, 2

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DATE: February 25, 1964
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VI. Microsyn Stator Potting

1. Refer to MC 25-507 for potting procedure. Follow MC 25-858 for the post cure and temperature cycling procedure.

2. Leak check the potted assembly using fixture A-87328. Maximum acceptable leak rate is 0.5 x 10^{-8} atm-cc/sec.

VII. Microsyn Grinding

A 1. Place a terminal pin protector A-109464 over the pins. Finish grind per drawings 2021649 and 2021663.

2. After the grinding operation, thoroughly clean the end housing assembly with an acid brush while immersed in warm varsol. Follow with a freon rinse.

3. Perform an electrical check and record on MC 25-858. Leak check. Maximum acceptable leak rate is 0.5 x 10^{-8} atm-cc/sec.

VIII. Pivot Bore Measurements

1. Using ball gages (A-122143) determine the pivot bore size and record __________.

B IX. End Housings are ready for testing per MC's 25-859, 25-860 and 25-866.

APOLLO II IRIG Specification
MC 25-859
Release Date Nov. 25, 1964
Release Revision A
Class A **Release**
TDRR 14531

Procedure for Testing
SG End Housing Assembly

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
2/12/65	B	16568	1, 2	WR	JBm 2/17/65

TP#11938

This MC specification consists of page i ~~to~~ ___ and 1 to 2 inclusive.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: G. Garcia
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DATE: February 25, 1964

MC 25-859

SHEET 1 OF 2

PROCEDURE FOR TESTING SG END HOUSING ASSEMBLY
APOLLO II IRIG

Rev. A 11/9/64 Rev. B 2/12/65

1.0 Preliminary

A 1.1 Mount rotor and stator on an air bearing torque test fixture. DRC-67-M-3 or equivalent.

1.2 Provision shall be made for maintaining the stator assembly at 135° ± 5%F during testing.

1.3 Rotor ID run-out to torque-summing member shall be 0.00005" TIR max.

A 1.4 Stator and rotor fixturing shall be such that the suspension air-gap can be adjusted.

2.0 Magnetic Suspension

2.1 Connect and excite the assembly per Figure 1.

2.2 Center the suspension radially by monitoring radial signals from transformers X and Y.

2.3 Center microsyn angularly by rotating stator with respect to rotor for minimum E_o.

2.4 Adjust axial height of stator until I_m lags V_1 by 45° ± 1° and

B I_m and I_{mn} = 41.5 ± 3 ma.

A 2.5 Disable SG primary and measure suspension reaction torque.

B Record. Limit is 0 ± 0.15 dyne-cm.

3.0 Signal Generator

B 3.1 Reconnect per Fig. 1. Disable suspension, and increase V_{in} to 4.0 v.

A 3.2 Rotate rotor to angles of 2 milliradians CW and CCW, calculating and recording the angular sensitivity and relative phase of E_o vs V_{in}.

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DATE: February 25, 1964

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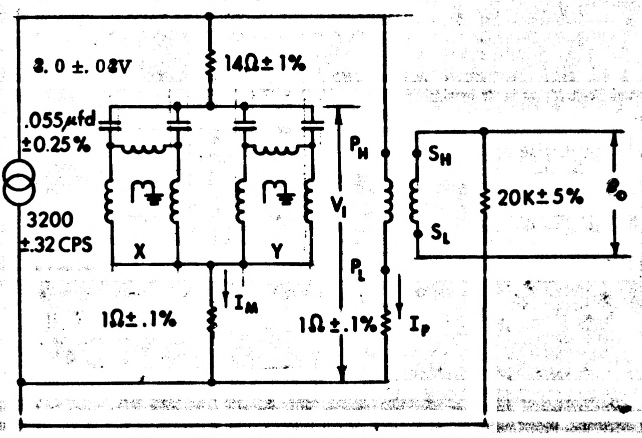
3.3 Rotate rotor to null E_o. Record null. Measure and record I_p.

3.4 Disable suspension. Measure and record SG reaction torque. Limit is 0 ± 0.05 dyne-cm.

A

B



No connections shall be made to quadrature or center tap terminals.

Fig. 1

APOLLO II IRIG Specification
MC 25-803
Release Date 25 Nov. 1964
Release Revision H
Class A Release
TDRR 145321

Mod 2 Wheel Assembly Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
5-12-65	J	19187	All Pages	WAL	WJR

TP#11938

This MC specification consists of page 1 to ___ and 1 to 20 inclusive.

Rev. F 5/17/63
Rev. E 4/25/63
H Rev. D 11/30/62
Rev. C 8/24/62
Rev. B 2/20/62
Rev. A 1/5/62
Rev. J 5/12/65
Rev. H 9/2/64
Rev. G 12/2/63

MOD 2 WHEEL ASSEMBLY PROCEDURE

1. Bearing Measurement

a) Bearings are to be received in the disassembled state with a set of components, outer race with matching balls, sealed in its individual package, and oiled with Teresso V-78 (SCD 2021550) oil to prevent rust. The geometry and material of the supplied retainers are specified by print B-87362, or 2021569 packaged separately and shipped dry.

b) Clean the outer races and shaft in the ultrasonic cleaner, using varsol as the cleaning agent, then rinsing the parts in trichloroethylene and freon. The bearing races and shaft should then be examined under a microscope for surface defects and embedded particles.

c) Set up the precisionaire column and air rings, check the sensitivity and then make at least 4 measurements of the O. D. of each outer race with a three jet ring. The outer races should be held at measuring room temperature along with the handling tools and measuring gages prior to measurement. Rotate the bearing approximately 45° between each reading. Measure the room temperature at which these O. D. measurements are made and record this information together with the O. D. measurements. Bearings which do not come within print specifications on roundness and match should be rejected at this stage. Average the values of the O. D. Set up the precisionaire column and air ring to measure the shaft .180000 diameter following the procedure outlined above.

d) Check the air gage with the Master gage plugs or rings after each measurement. If the air gage has drifted, readjust and remeasure the outer race O. D. or the shaft .180000 diameter.

e) Oil the outer races and shaft and package with the corresponding balls and retainer. The hypodermic syringe used to oil the races should have an integral filter assembly similar to the millipore XX30 01200 Swinney Hypodermic Adaptor. The oil should be Teresso V-78 which has been taken from a bottle filled after oil filtration. It is suggested that the oil be discarded after a two month use period.

f) Seal the bearings in clean plastic bags, replace in original outer package and store until ready to use.

g) Identify the outer package with a number and record the diameters of the bearing races and shaft, together with the temperature at which they were measured, on the outside of the bearing package.

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Equipment

Ultrasonic Cleaner
Plastic Bags
AMSCO Bag Sealer
E Master Gage Plugs, Class XXX (.180000, .180020)
Sheffield Air Ring with two small jets for measuring the .180000-.180030 diameter.
Sheffield Precisionaire Column, 40,000-1 Amplification, Model 153-40 with Booster.
Sheffield Air Ring with three small jets equally spaced for measuring .3748-.3749 diameter Air Ring mounted on stand with axis vertical (Sheffield S.O. 663680).
E Master Gage Plugs, Class XXX (.3748, .3749)
Thermometer
Stainless Steel Forceps with Composition Tips
Hypodermic Syringe with Millipore XX30 01200 Swinney Hypodermic Adapter and 0.45 micron Millipore Filter.

2. Inertia Element Assembly

a) Check inspection report on wheel hub, hysteresis ring and inertia rims.

b) Clean parts in ultrasonic cleaner.

c) Select parts that meet required tolerances. Required fits and weights are shown on the wheel assembly data sheet (M. C. #25-603).

d) Place one inertia rim (O. D. chamfered end down) and the hysteresis ring in fixture B-87392.

e) Place this assembly on a hot plate and by means of a thermocouple check the temperature. When the thermocouple indicates a temperature of about 200°F immerse wheel hub into liquid nitrogen, until temperature stabilization takes place.

f) With a pair of tweezers lift wheel hub out of nitrogen and place hub bore over fixture guide post.

g) Let wheel hub slide over this post by its own weight.

h) Remove this assembly from fixture, and insert the second inertia rim (O. D. chamfered end down) into fixture and repeat steps d through g.

i) Remove the completed inertia element assembly and inspect for possible gaps between inertia rims and hysteresis ring. If gaps are present place inertia assembly back into fixture. Close gaps using sleeve A-87392.5 and an arbor press by pressing against the sleeve while rotating fixture.

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Rev. B 2/20/62
Rev. A 1/5/62

NOTE: It may be necessary to adjust the nut on the fixture to insure equal overhang of both inertia rims.

Equipment

Ultrasonic cleaner
Mettler balance
Inertia element assembly fixture
Depth micrometer
Thermocouple
Hot plate
Tweezers
Drake Arbor Press

3. Temperature Cycling

a) Wrap wheel assembly in aluminum foil.

b) Place in the cycling container, #2A3-10B177, evacuate container for 5 minutes to an absolute pressure of 1/2 to 1 psi; seal off container and put in temperature cycling chamber.

c) Cycle the wheel assembly four times between -60°F and +200°F.

Equipment:

Cycling container
Tenney Test Chamber
Reynolds Aluminum Foil

4. Lapping Bearing Bores

a) Measure the lapping room temperature and, using the wheel assembly data sheet (M. C. 25-603), determine the required size of the wheel bore at lapping room temperature to give a line on line fit at operating temperature.

b) Measure the wheel bore for size and roundness, using the Sheffield Precisionaire Column with 40,000-1 Amplification, Model 153-40.

c) If out of round, true up the bore with a hand lap and 38-1200 lapping compound and olive oil or E oil. Hand lap the wheel bore to the final dimensions desired, being careful not to overshoot the required diameter and to maintain roundness. The finished bore should be round and to the calculated diameter within 10 microinches. The bell-mouth of the bore as measured on the Pratt & Whitney Electrolimit Universal Internal Comparator should not exceed 20 microinches, and should not extend more than .040" in length. Use a thru lap to minimize bell-mouthing and to keep the bores in line. The last 20 microinches should be lapped out using olive oil or E oil only, no abrasive compound.

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Rev. B 2/20/62
Rev. A 1/5/62

d) Record the actual finished bore size on the wheel assembly data sheet (M. C. 25-603).

e) Place the inertia element assembly in a vacuum oven at 150°F and evacuate for one hour at full vacuum, after cleaning in ultrasonic cleaner.

Equipment

Thermometer
Sheffield Precisionaire Column, 40,000-1 Amplification.
  Model 153-40 used with small jet spindles and Class XXX Master Gage Rings
Hand Lap - 3/8" dia. x 3" long - American Lap Co.
Lapping Compound 38-1200 - U. S. Products Co.
Olive oil or
Mobil Velocite E oil - Socony Mobil Oil Co., Inc.
Zeiss Stereo Microscope
Vacuum Oven - Precision Scientific Co.
Pratt and Whitney Electrolimit Universal Internal Comparator
Ultrasonic cleaner

H

5. Numbering Wheel (If Inertia Rim not previously numbered)

a) Using an Electric Etcher, scribe identification numbers or symbols equally spaced (60° approx.) on the face of the inertia rim of the number two end of the inertia element assembly. (The #2 end of the inertia element assembly is that end chosen for the number two bearing).

Important: Extreme care should be taken to insure that no burrs are raised during this operation and the face of the wheel hub should be free of any marking. This is extremely important because that face of the wheel hub will contact the mechanical compliance fixture.

b) Mark the wheel in a similar manner on the opposite end face of the inertia rim with the wheel identification number (e. g. C-29)

Equipment

Ideal Electric Etcher Mod. No. 11-009 by Ideal Industries Inc., Sycamore, Illinois

6. B Dimension Measurement (Dimension over the Hub)

Using a 0.975000 gage block and the Johansson Mikrokator S 510 E-8, measure accurately (to within 5 microinches) dimension B and parallelism of the two faces of the wheel hub. Make sure that gage blocks and wheel hub are firmly wrung on to the Mkirokator reference block.

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Rev. B 2/20/62
Rev. A 1/5/62

Equipment

C. E. Johansson Mikrokator S510E-8
Gage blocks

7. Contact Angle Measurement by Inner Race Rotation

a) Clean bearing assemblies as in paragraph 12 M. C. 25-803, steps a and b.

b) Assemble outer races as in paragraph 13 M. C. 25-803. For this measurement tapered or stepped pocket retainers can be used for assembly convenience. Important: If tapered or stepped pocket retainers are used, insure that interference is reduced to a minimum by predenting the ball pockets, eliminating possible ball damage during assembly. The retainers must be impregnated and centrifuged. Regardless of the type of retainer used for this measurement, these retainers must not be used in the final bearing assembly.

c) Install the shaft and the mating outer race in fixture D-95850 and rotate the shaft thirty revolutions and record the corresponding revolutions of the retainer. Repeat this measurement two to three times to insure repeatability.

d) Determine the contact angle using the following formula:

$$\text{Cos } B = \frac{E}{d}\left[1 - \frac{2NE}{No}\right]$$

Where E = pitch diameter 0.24945 (print nominal value)
d = ball diameter
No = number of inner race revolutions
NE = number of retainer revolutions
NOTE: This formula applies to inner race rotation only.

Equipment

Contact Angle Gage

8. Preload Spacer Thickness Selection

With dimension A as recorded on bearing package by manufacturer, and dimension B as measured here in section 6, determine spacer thickness by using the following simple formula:

$$A = B + t - 65 \text{ microinches}$$
$$\text{or } t = A - B + 65 \text{ microinches}$$

where t is the spacer thickness and the 65 microinches shaft deformation is explained in section 14.

---

9. Retainer Impregnation

E

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and 30 inches vacuum for five hours, minimum, to completely remove all traces of water and solvent contents.

b) Remove one retainer at a time from the oven and weigh immediately. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and 27 ± 1/2 inches vacuum, outgas the retainers and oil for approximately one hour.

d) Immerse retainers in oil and hold for an additional two hours, or until all bubbling ceases.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for two hours.

9A. Retainer Impregnation (Alternate)

a) Clean retainers in ultrasonic cleaner using varsol followed by a freon rinse. Assign numbers to retainers and place them in vacuum oven at 150°F and a minimum of 29 inches vacuum for 18 hours, minimum.

b) Remove the retainers from the oven and weigh each one within 10 to 30 minutes after exposure to the atmosphere. Replace retainers in oven and record weights and corresponding retainer numbers.

c) Place container with filtered Teresso V-78 oil under the suspended retainers. With the oven set at 150°F and evacuate to 29.0 to 29.8 inches vacuum for a minimum of 1 hour.

d) Immerse retainers in oil and hold for an additional 2 to 3 hours.

e) Stop vacuum pump and open valve to vent to atmosphere. The vent line should have a 0.8 micron Millipore filter.

f) Remove retainers and oil from oven and allow retainers to remain in oil for 2 to 3 hours.

10. Retainer Centrifuge - (see Appendix A)

Equipment

International Centrifuge, Model MB, Inter. Equip. Co., Boston, Massachusetts.

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in container assemblies #2A3-10A187-1 always keeping track of the assigned numbers, and place these assemblies in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

E

b) Remove from oven and install assemblies into centrifuge plate #2A3-10C187-1, and spin for 10 minutes at 6140 rpm (4000 g's).

c) Remove retainers from containers and clean container assemblies ultrasonically. Replace retainers in container assemblies, this time with opposite faces out, and repeat steps a and b.

d) Place retainers between two pieces of lens tissue and store in oven at 150°F for five hours.

e) Remove retainers one at a time from oven, reweigh, and compute absorption of individual retainer as follows:

$$\%\text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = weight of retainer after baking.
W_2 = weight of retainer after centrifuging.

Acceptable oil absorption values are in the range of 2 to 5%.

E

f) Retainers shall be vacuum baked for five hours at 150°F immediately prior to bearing assembly.

10A Retainer Centrifuge (Alternate)

Centrifuge retainers for twenty minutes at 4000 g's as follows:

a) Install retainers in centrifuge cups, always keeping track of the assigned numbers, and place these in oven. Heat assemblies to 150°F, allowing 15-20 minutes for temperature to stabilize.

b) Remove from oven and install assemblies into centrifuge plate, and spin for 10 minutes at 4000 g's.

c) Remove retainers from centrifuge cups and clean cup assemblies ultrasonically. Replace retainers in centrifuge cups, this time with opposite faces out, and repeat steps a and b.

d) Remove retainers from centrifuge cups and wrap each one securely in lens tissue. Place in the vacuum oven for 30 minutes maximum at 150°F and 29-29.8 inches of vacuum. Change lens tissue and repeat evacuation for 30 minutes maximum.

e) Reweigh each retainer between 10 and 30 minutes and compute the absorption of individual retainers as follows:

$$\% \text{ absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

where W_1 = original weight of the retainer after baking.

W_2 = weight of retainer after vacuum blotting.

f) If the % absorption is too high or the retainer visually appears to be excessively oily, proceed to step g.

g) Wrap the retainer securely in lens tissue and place in an oven at 150 F for 6 hours. Reweigh and compute % absorption as in step e.

h) Acceptable oil absorption values are in the range of 1.5% to 5.0%.

11. Final Cleaning

a) Examine bearing retainers very carefully under a microscope to insure that no foreign material is present on the retainer surfaces and ball pockets; a needle and magnet can be used to remove foreign particles.

b) Clean all bearing assembly parts, except retainers, with the ultrasonic cleaner using trichlorethylene. Rinse in freon until all parts are thoroughly clean, and examine under a microscope.

E c) Clean wheel inertia element, spacer caps and screws using ultrasonic cleaner and examine under a microscope.

12. Outer Race Assembly

Assemble retainers, balls and outer races as follows:

a) Install retainer over the guide post of fixture #1A3-10B150.

b) Place plug #A-92243 inside the retainer and insert balls in the retainer ball pockets.

c) Drop outer race over this assembly and press the outer race over the balls with a pair of bone tweezers.

NOTE: During this operation be careful to insure that balls are assembled with the corresponding outer races to prevent improper contact angles, resulting when outer races are mated with unmatched shaft ends.

d) Assemble the second bearing by repeating steps a, b, and c.

Equipment

1) Fixture #1A3-10B150
2) Plug #A-92243
3) Bone Tweezers

13. Bearing Installation

E a) Place the wheel assembly on the holding fixture #A-88948.3 with the bore that was lapped to fit bearing marked II in the up position.

IMPORTANT: The orientation of the outer race faces during assembly is very important. Assemble outer races with stamped faces inward.

b) Lay the bearing marked II on the bore and with bone tweezers press lightly on the edge of the bearing to start the bearing square to the bore preventing bearing cocking.

H c) Place a spacer B-97652 or 2021667 over the bearing and use fixtures A-88948.1 and A-88948.2 to press the bearing into the bore. The force necessary to push the bearing into the bore will be in the range of 3-8 pounds (reference).

d) Remove the spacer and place the beryllium cap on top of the bearing. Using the fixtures described in step c above, press bearing into its final position.

e) Fasten beryllium cap on the wheel by installing and tightening the four screws hand tight.

f) Remove wheel from bearing installation fixture and hold in a vertical position with the installed bearing facing up.

E g) Screw adaptor A-92246.2 into end I of the bearing shaft and holding only the adaptor, guide the shaft through the wheel bore until the shaft end marked II replaces the plug inside bearing II. The wheel now is supported by the shaft. Reverse the position of the wheel and place this assembly on the fixture.

h) Place the second bearing over the shaft. When the plug comes in contact with the shaft insure that plug and shaft are well lined up. Maintain this position by pressing very lightly on the plug while lowering the bearing into position with the other hand.

i) Repeat step b above for bearing number 1.

j) Select a spacer 0.0005" thicker than the calculated size and use fixture A-88948.1 and A-88948.2 to press the bearing into the bore (the use of a thicker spacer is suggested to prevent brinelling of the bearings in case of error in measurements).

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k) Remove this spacer and substitute the proper size spacer as determined in paragraph 8.

H l) Install beryllium cap and insert four 0-80 Allen Head screws .187 long. Advance the bearing by turning the screws slowly, frequently checking the shaft end play. Stop turning the screws when the shaft end play is reduced to a minimum, without, however, placing any preload on the bearings.

m) Remove screws, beryllium cap, and spacer.

14. Shaft strain

In order to provide a nominal 50 pound tensile load in the shaft as installed in the float, some prestraining of each wheel shaft will be necessary.

The compliance of the .207 diameter center section of the shaft is 1.3 microinches/lb and the distance between raceways is .850". Therefore the 1.3 microinch/lb compliance at a 50 pound tensile load will give approximately 65 microinches deformation (76 microinches/inch over the .850 length).

The 65 microinch shaft deformation may be achieved as follows:

H a) Insert a 416 stainless steel rod (.093 diameter x 1.270 ± 0.001 long) into the .101 shaft I.D. Optional MTL: 52100 steel.

b) Assemble top adaptor #A-92246.1 to the II shaft end with the flat end inward and tighten to a torque of 0.75 in. lb (strain gage measurements at M.I.T. indicate that 0.75 in.lb or torque produce 76 microinches/inch shaft strain and correspondingly approximate 65 microinches shaft deformation).

The 65 microinches shaft strain will be maintained during all subsequent assembly operations up to installation in the float, i.e. the adaptors and shaft will not be removed until that time.

15. Final spacer selection (Preload Fixture D-92272)

a) Assemble shaft adaptor #A-92278, to the #2 end of wheel.

b) Assemble shaft cap #A-92277 to the #1 end of wheel. In assembly of these adaptors insure that the applied torque does not exceed 0.75 in. lb.

c) Position wheel on top plate #C-94190, the chain that is attached to shaft adaptor #A-92278, should protrude through the bottom of the plate #C-94190.

d) Place clamping ring #B-94185, on top of wheel insuring that the teflon washer #A-94186 contacts the wheel hub only. Insert clamping screws into provided tapped holes and apply very small and equal torque values on each screw to avoid possible cocking of the wheel.

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e) Attach weight pan #A-92281 to chain hanging from shaft adaptor #A-92278.

f) Place tip of Mikrokator on top of wheel hub and measure fixture deflection by applying six pounds load. Lift weight and zero meter and then gently apply the six pound load. Insure that the swinging or rotation of the applied load is minimized so as not to affect the reading. Take measurements at four different positions approximately 90° from each other. The difference of all four measurements should not be greater than five microinches. Take the average of these measurements and record.

NOTE: If the difference in measurements is greater than the specified five microinches, this is an indication of improper installation of the wheel. Loosen clamping screw and reposition wheel.

g) Remove Mikrokator tip from wheel hub and insert spacer of thickness t (see 8) and beryllium cap on wheel hub. Position the beryllium cap by inserting the #0-80 Allen head screws. At this time do not tighten the screws against the cap.

h) Place Mikrokator tip on the high point of shaft cap #A-92277.

i) Apply three pounds axial load and record the Mikrokator meter reading. This is the reference point to be referred to later. Lift the weight and gently apply the load again to test the repeatability of the reference point. Once repeatability has been established and the reference point recorded, lift the weight and support it on a block so that there is no load on the bearing.

j) Using an Allen wrench, carefully tighten the screws until the beryllium cap and spacer combination is firmly seated on the wheel hub.

IMPORTANT: During this operation extreme care should be taken to insure that no part of the apparatus is disturbed.

k) Rotate the bearing shaft approximately 10 revolutions before recording the mikrokator deflection. If the difference between this measurement and the reference established in step (i) is within ±10 microinches, the proper preload has been achieved. If not, change the spacer thickness by an amount equal to twice the difference between the final indicated measurement and the reference. Repeat the measurement.

H l) Measure axial compliance by hanging one, three, and four pound weights on the shaft end and recording the displacement of the indicator from zero for each weight. These displacements, corrected for fixture compliance, should be points on a linear curve and within the "reference" values of 8.4 to 12.6 microinches per pound. Record axial compliance on MC-811.

16. Dynamic Balancing (Preliminary)

NOTE: Balancing may be performed after temperature cycle (17).

a) Remove the wheel from the compliance fixture and mount in Dynamic Balancing Machine. Adjust excitation gain to turn wheel over slowly (60 rpm) approximately for one minute to lubricate the dry metal parts.

b) Dynamically balance the wheel until the residual unbalance is no greater than 0.25 dyne-cm. The corrections should be made by filing the O. D. of the inertia rms with the correction planes as far apart as possible. Prior to making balance corrections both ends of the wheel must be carefully sealed off with rubber cups to protect the bearings.

c) Examine the areas of the wheel and bearing shaft under a microscope and remove any trace of contamination. Before removing cups, clean the wheel thoroughly with suction hose.

d) Check the sensitivity of the balancer at regular intervals according to the manufacturer's recommendation.

Equipment

Micro Balancing Model K-1 Dynamic Balancing Machine
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alt: Schenk Balancer Model #R-06

17. Temperature Cycling (Bearings Installed)

a) Wrap wheel in aluminum foil, and place in the cycling container, 2A3-10B177.

b) Evacuate the cycling container to an absolute pressure of 1/2 to 1 psi, seal off container and put in temperature cycling chamber.

Alt: Temperature cycle may be performed in 5 to 10 psig helium atmosphere

c) Cycle the wheel assembly four times between +40°F and 180°F.

Alt Cycle: 32°F to 180°F

d) Refer to MC 25-838 for dynamometer testing.

Equipment

Cycling Container — Tenney Test Chamber or Equivalent
Reynolds Aluminum Foil
Vacuum Pump

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18. Sealing Cap Screws

Remove wheel from the dynamometer and place it in stand #A-88948.3. Remove Allen head screws on number one end of wheel, and insert cap centering ring #A-92244, around cap and wheel hub neck to eliminate cap run-out. With the cap now well centered, insert final 0-80 screws and tighten firmly. Remove cap holding screws one at a time, and with a very small drop of Loctite, tough the first thread of the tapped hole of the wheel hub. Allow Loctite to run through the threads. Replace screw and fasten firmly.

a) With a microscope examine the area around the screw head and wipe off any excess Loctite. (Loctite will not cure if exposed to air). Repeat this procedure to all 8 screws.

Alt: LCA-4 (2021552) may be used as a substitute for Loctite..

b) To speed up Loctite cure cover wheel with aluminum foil and place in oven for one hour at 150°F.

Equipment

1) Fixtures #A-88948.3, A-92244.
2) Bone tweezers.
3) Jeweler's screw driver.
4) Loctite sealant
American Sealants Co., Hartford 11, Connecticut
5) LCA-4 per SCD 2021552

19. Dynamic Balancing (Final)

a) Check the final balance of the wheel as in paragraph 16 and make necessary corrections to achieve a maximum residual unbalance of 0.10 dyne-cm. Also measure and record the bearing noise level.

NOTE: This check should be made with the wheel at operating temperature as follows:

To bring the wheel to operating temperature during balancing:

1) Attach thermocouple wire with calibrated Alnor meter to center of O. D. of stator housing.
2) Cover the stator housing and entire rotor platform with a foil lined beaker.
3) Run the wheel at synchronous speed until the Alnor meter indicates 155° - 160°F. Wheel temperature will now be within the operating limits.

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Equipment

Micro Dynamic Balancer, Model K-1
Micro Balancing, Inc.
Garden City Park, Long Island, New York
(includes sp. fixture supp. by Mfg. for mounting wheel)
Alnor Meter
Alt: Schenk Balancer Model #R-06

20. Final Inspection

a) Place wheel under microscope and inspect for lint and dust particles.

b) Clean off with vacuum hose and repeat (a).

c) Place the wheel in a plastic bag and hermetically seal in a vacuum.

Equipment

Zeiss Stereo Microscope
Vacuum hose
Plastic bag
AMSCO Bag Seal
} or Equivalent

21. Installation in Float

Install the wheel into the float according to the Float Assembly Procedure MC #25-810 or MC #25-855.

A mechanical axial compliance for the wheel was established in paragraph 15. To reestablish this axial compliance in the float, proceed as follows:

a) Assemble adapter #A-95721, firmly to the VS-10.

b) Thread lock-nut #A-92357, to the 12-72 stud until it bottoms.

c) Assemble the (-) SRA end of the float to adapter #A-95721 very carefully until it bottoms, then back the float off one full turn.

d) Fasten the float by bottoming lock-out #A-92357 firmly against the bushing, using spanner wrench #A-92359.

e) Set variable frequency oscillator at 1500 cps and adjust oscillator gain so that the output voltage of the amplifier is 470-580 mv.

IMPORTANT: This level of amplifier output voltage will provide the necessary energy and is also safe for the bearings. Any higher voltage might brinell the bearings.

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f) Turn the variable frequency oscillator slowly across the frequency range from 2000 to 3400 cps. The wheel resonant frequency can be accurately determined when the V. T. V. M. reaches a peak. At this point stop turning the oscillator dial and read the resonant frequency on the electronic counter. Repeat step f three times and take the average of the resonant frequencies.

g) Using this resonant frequency and curve (sheet 22), determine the axial compliance of the wheel.

h) This compliance is to be adjusted to agree with the mechanical axial compliance value recorded on M. C. #811 within ± 0.25 microinch/lb.

i) If the axial compliance as determined in step (g) above is higher than the compliance recorded on M. C. #811, insert wrench #A-92262 in the +SRA bushing and lock wrench firmly by turning locking screw.

j) Increase the torque value by one inch-lb. (A torque of three inch-lbs was applied to the shaft when the wheel installed in the float). Remove wrench #A-92262, and steps f and g. Repeat this step if necessary until the required compliance is achieved.

NOTE: If the compliance as determined in step (g) is lower than that recorded on M. C. #811, insert wrench #A-92262, and remove completely the three inch-lb torque and retorque the bushing with two inch-lbs. Remove torque adapter and repeat steps f and g. It is suggested that the torque values are increased in increments of one inch-lb at a time until the required compliance is achieved.

k) With the axial compliance determined, remove float from VS-10 and fasten one of the IA balance ports to the VS-10 as is steps c and d.

l) Determine the radial compliance repeating steps f and g.

m) Record both axial and radial compliances in M. C. #25-605.

A wheel is satisfactorily isoelastic if the difference, of the radial and axial compliances, Δ C, is equal to or less than 0.75 microinches/lb. If the term Δ C is greater than 0.75 microinches/lb., the wheel is considered anisoelastic and should be removed from the float.

If the wheel is isoelastic return the float to the float assembly area for temperature cycling from 40° to 180°F at 3°/min. max. rate (4 cycles). Alternate cycle 32°F to 180°F at 4°/min max.

After temperature cycling install the float in the VS-10 and recheck the axial compliance as described earlier in this paragraph. The measured axial compliance must be within ±0.5 microinches/lb. of the value recorded in M. C. #811. If the compliance is outside the imposed limits, the float should be re-torqued and recycled until stability has been insured. If the compliance meets specifications remove the -SRA bushing and loosen the +SRA bushing.

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H n) Using a spade oiler, or other suitable tool, apply LCA 9, (SCD 2021529) MC 25-302, to the -SRA bushing and torque to 5 inch pounds.

o) Remove the +SRA bushing and repeat the cementing operation per step n, replace the +SRA bushing and torque to 3 inch pounds.

p) Repeat steps a through m as necessary to reset compliance. (Note: the torque required at this time will be higher than the initial torque).

q) Cure assembly for 2 hours at 180°F maximum.

r) Recheck compliance after cure and record on MC 25-605.

22. Final Run-In

a) Insert the thermistor holder #2A3-10A180-1. 2 with the Fenwal Thermistor probe, into one of the IA balance ports.

b) Install the float into fixture #C-87364 and attach power and thermistor leads onto provided terminal strip.

c) Install top plate #A-87364. 1 on top of the float.

d) Turn the power supply and heater on and set the Fenwal indicator at 137 . After one hour of wheel running, take run-down time and run-up time measurements per MC 25-834. Record these measurements and all other parameters called out on MC 25-605.

The speed and inertia of the Mod 2 wheel affect greatly the spread of the run-down measurements if taken from 24000-0 rpm. For this reason the run-down time measurements will be taken from 24000-6000 rpm and 6000-0 rpm. To do this, follow the following procedure:

1) Insure that the oscillator of the wheel power supply is 800±3 cps, and take a run-down time measurement as per MC 25-834.

H Run-down time measurements should be taken twice in every 24 hour period with a minimum of 4 hours between measurements and recorded on MC 25-605. The total wheel run-in time, including dynamometer should be 200 hours. This should include 120 hours minimum of dynamometer time and a minimum of 80 hours of float time since the last torquing or cycling.

F When the wheel has completed its run-in period the average wheel run-down time (A_F) and the rms of the deviations from average can be computed. The only imposed run-down time limit is $6_F \leq 4.0$

$$\text{where } 6_F = \sqrt{\frac{(T_1 - A_F)^2 + (T_2 - A_F)^2 + \ldots\ldots\ldots (T_n - A_F)^2}{n}}$$

A_F = average run-down time to 6000 rpm.

n = number of run-down time checks (no less than 7)

T_n = RDT to 6000 rpm

NOTE: During the 80 hour minimum run-in period observe carefully the values of --a) power input, b) run-up time and c) run-down time. The run-up time should be taken with the voltage fixed at 28 volts, and it should repeat within one to ten seconds.

Decreasing or erratic run-down times are indicative of incipient bearing failures. Ensure that the trouble is not external to the wheel (faulty electronics, poor electrical connection, etc.); then, if the condition continues, reject the float assembly.

23. Delivery

Continue float assembly per MC 25-810 or MC 25-855.

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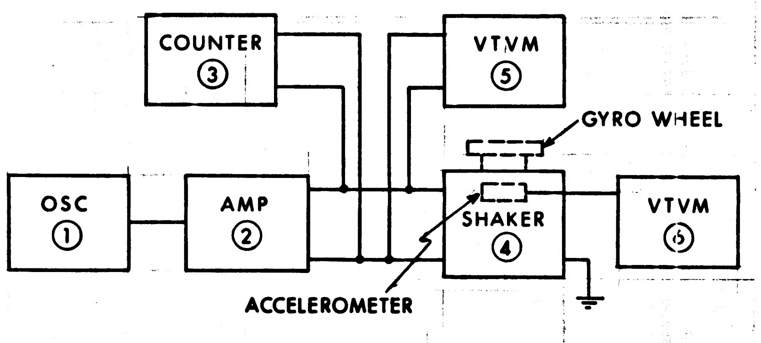
Compliance Checking Equipment

Mod 2 Gyro



1. Oscillator - Hewlett Packard Model 204B
2. Amplifier - McIntosh 30 Watt
3. Counter - Beckman Universal Eput and Timer Model 7360
4. Shaker Table - Vibrasonics Inc. Type Model VS-10
5. V. T. V. M. - Hewlett Packard Model 400H
6. V. T. V. M. - Ballentine Model 300E

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APPENDIX "A"

CENTRIFUGE

$$\text{"G" level} = \frac{w^2 r}{g}$$

w = rad/sec
r = inches
g = 386 in/sec^2

$$w = N \frac{\text{Rev}}{\text{Min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times 2\pi \frac{\text{rad}}{\text{rev}}$$

$$w = N \frac{\pi}{30}$$

$$\text{"G" level} = \frac{\left(\frac{N\pi}{30}\right)^2 r}{g}$$

N = rpm
r = inches
g = 386 in/sec^2

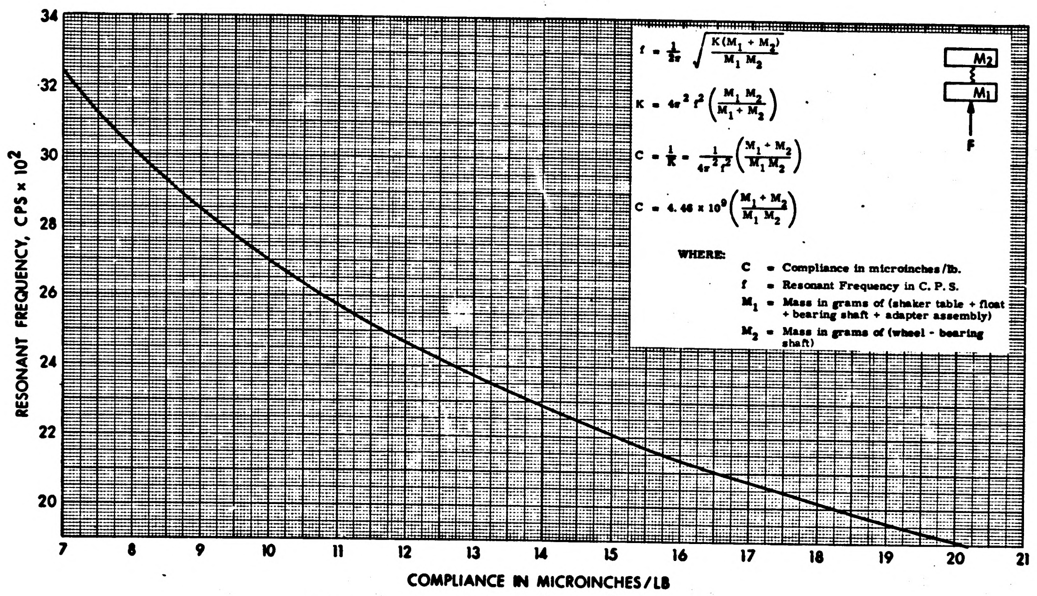
Rev J 5/17/65

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

PREPARED BY: J. Psyhogeos
DATE: January 5, 1962

MC 25-803

SHEET 20 OF 20



$$f = \frac{1}{2\pi}\sqrt{\frac{K(M_1 + M_2)}{M_1 M_2}}$$

$$K = 4\pi^2 f^2 \left(\frac{M_1 M_2}{M_1 + M_2}\right)$$

$$C = \frac{1}{K} = \frac{1}{4\pi^2 f^2}\left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

$$C = 4.46 \times 10^9 \left(\frac{M_1 + M_2}{M_1 M_2}\right)$$

WHERE:

C = Compliance in microinches/lb.
f = Resonant Frequency in C. P. S.
M_1 = Mass in grams of (shaker table + float + bearing shaft + adapter assembly)
M_2 = Mass in grams of (wheel - bearing shaft)

RESONANT FREQUENCY VS. COMPLIANCE

For Wheel in Float
Measured by VS-10

IL 27

TDRR No. 94 35594

BELLOWS
(Dwg. 2001688)

1. GENERAL

1.1 Scope

This specification establishes the requirements for procurement of the bellows used in the 16 PIP Mod D (dwg. 2001652).

1.2 Description

This bellows is intended for use in a hermetically-sealed, fluid-filled instrument. Four bellows are used in each instrument. The bellows is a four-convolution, chemically deposited 95% nickel structure, helium filled and hermetically sealed.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein:

MIT/IL Drawing	
2001688	Bellows
Military Specifications	
MIL-D-70327	Drawings, Engineering and Associated Lists
Federal Specifications	
QQ-S-571	Solder: Tin Alloy; Lead Tin Alloy: and Lead Alloy
QQ-B-613	Brass, Leaded and Non-leaded; Flat Products (Plate, Bar, Sheet, and Strip)

REVISIONS

REVISION	DESCRIPTION	APPROVED BY	DATE

ENGINEERING APPROVAL

PREPARED BY K. Ziegler APPROVED BY

APPROVED BY GROUP LEADER DATE Feb 6 '61

QQ-A-225/8c	Aluminum Alloy Bar, Rod, Wire and Special Shapes; Rolled, Drawn, Cold Finished, 6061
BB-H-001168	Helium, Technical

3. REQUIREMENTS

3.1 General

3.1.1 The quantity to be delivered shall be as specified in the purchase order.

3.2 Design

3.2.1 Material

(1) The bellows shell shall be made of chemically deposited "Mechmetal", a 95% nickel proprietary material.

(2) The header shall be produced from brass per QQ-B-613.

(3) The mandrel used to generate the bellows shape shall be manufactured from aluminum per QQ-A-225/8c.

(4) The solder used to seal the unit shall be type SN 63 per QQ-S-571.

(5) The helium used to fill the unit shall be in accordance with BB-H-001168; type 1, grade A.

3.2.2 Configuration

The unit shall meet the dimensional requirements of drawing 2001688.

3.2.3 Permeability

The permeability of the completed bellows shall be 1.15 maximum.

3.2.4 Volumetric Compensation

The bellows shall have a total volumetric compensation of 0.0013 cubic inch (0.021 cc) minimum.

3.2.5 Hermetic Integrity

The bellows shall have a maximum leak rate of 10^{-9} std cc/sec (helium).

3.2.6 Environmental Integrity

All requirements of this specification and the associated drawing shall be met after consecutive exposure to the following conditions:

(1) External pressure of 0.4 psia maximum for 72 hours at 190°F minimum with the bellows length limited to 0.135/0.140 inch.

(2) External pressure of 20 psia minimum for 20 hours at 190°F minimum.

(3) External pressure cycling from 0.4 psia maximum to 45 ± 5 psia for 5000 cycles at a maximum rate of 60 cycles per minute.

3.3 Fabrication

3.3.1 Workmanship

The supplier shall maintain good workmanship standards and practices throughout fabrication and testing of the bellows. There shall be no burrs, poorly soldered joints, discoloration, flux or associated soldering side products or any other evidence of poor workmanship. The exterior surfaces shall have no protuberances or discontinuities detrimental to proper operation of the bellows and shall contain no flaking material which might generate contamination. The fill hole shall be drilled carefully to minimize spikes and contamination inside the bellows. No more than two fill holes per bellows shall be permitted.

3.3.2 Identification

Each unit shall be identified by a serial number which will be assigned in a non-recurring sequential series. The manufacturer's symbol may be used as an integral part of each serial number. The serial number will be applied to a tag attached to each container.

3.3.3 Traceability

The manufacturer shall maintain traceability records which shall, as a minimum, identify each bellows serial number with respect to the lot number of the mandrel material and lot number, date and the corresponding process control Q. A. signature of the deposition process. Information from these records shall be made available to the buyer upon request.

4. QUALITY ASSURANCE

4.1 General

The bellows shall be purchased only from qualified sources.

The drawings and specifications prepared by the supplier to control the manufacture of the bellows shall not be changed after qualification, except as specifically approved and authorized in writing by the buyer prior to incorporation. A listing of these drawings and specifications shall be provided to the buyer upon request.

4.2 Qualification of Supplier

4.2.1 Initial Qualification

The supplier shall select at random a minimum quantity of ten units from at least two deposition lots as a sample for qualification testing. The supplier shall test the qualification samples for compliance with all of the requirements stated in Section 3 of this specification. Satisfactory results by each sample shall qualify the supplier.

4.2.2 Periodic Requalification

Each new purchase order requires a requalification. The requalification requirement consists of a repetition of the initial qualification test on a new sample in accordance with para. 4.2.1.

4.2.3 Requalification

In the event of a change affecting the construction or manufacture of the bellows, or of the submission of a new design by a disqualified supplier, requalification shall be required. The procedure and requirements for initial qualification shall apply.

4.2.4 Test Data

The manufacturer shall supply the test data taken during qualification testing to the buyer and receive notification of qualification approval prior to initiating delivery.

4.3 Lot Acceptance Criteria

4.3.1 In-Process Requirements

(1) Bellows Shell Leak Test

A leak check will be performed on each bellows shell in accordance with para. 5.2.3. The helium pressure shall be 60 psia minimum. Compression of the bellows during the test shall be limited to an overall length of 0.078 to 0.135 inch. Shells showing a leak rate in excess of 10^{-9} std cc/sec shall be rejected. In addition, a reject percentage per deposition lot in excess of 10% shall require rejection of the entire lot.

(2) Assembled and Filled Bellows Leak Test

A leak check of the completed bellows shall be performed in accordance with the para. 5.2.3 no longer than 30 minutes after removal of the bellows from the helium fill fixture. The acceptable leak rate limit shall be 10^{-9} std cc/sec.

4.3.2 Final Acceptance Requirements

Each bellows shall be subject to the tests and inspections listed below. Acceptance of units by the buyer shall be based on the manufacturer's test data provided to the buyer and the results of acceptance tests performed by the buyer.

(1) Visual inspection per para. 5.2.1.

(2) Volumetric compensation test per para. 5.2.2.

(3) Environmental tests per para. 5.2.3.

(4) Leak test per para. 5.2.4.

(5) Radiographic inspection per para. 4.4.

4.4 Radiographic Inspection Technique

4.4.1 Responsibility for Performance of Inspection

Unless otherwise specified, the vendor shall be responsible for the performance of all inspection requirements prior to submission for contractor inspection and acceptance. Unless otherwise specified, the vendor may use his own facilities if acceptable to the contractor, or any laboratory acceptable to the contractor.

4.4.2 Frequency of Inspection

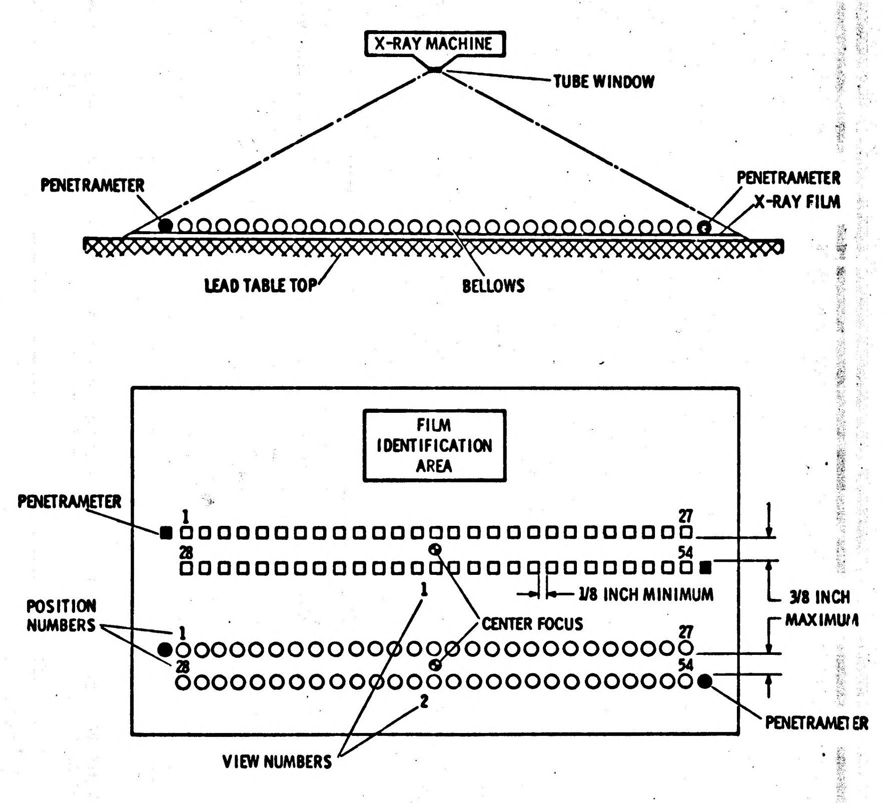
Unless otherwise specified, radiographic inspection shall be performed on each finished item (bellows) after all manufacturing operations and acceptance tests have been performed.

4.4.3 Radiographic Views

Two views of each item shall be required. One view shall be perpendicular to the main axis of the item and the second view shall be along the main axis of the item.

4.4.4 Radiographic Layout

Items should be arranged for radiography as shown in Fig. 1. Any layout other than that shown in Fig. 1 shall require specific approval of the contractor.



NOTE: Only two rows per radiographic view is permissible.

Fig. 1 Typical Radiograph Layout.

4.4.5 Radiographic Lot

Items shall be grouped in radiographic lots for radiographic inspection. The maximum number of items in each radiographic lot shall be determined by the number of items which can be grouped to meet the spacing requirements shown in Fig. 1. All items in any one radiographic lot shall be of the same design and shall be for the same purchase order.

4.4.6 Film Identification

The radiographic position numbers shall be radiographed at the beginning and end of each row of items on the film. Unless otherwise specified, the following information shall also be radiographed:

(a) radiographic laboratory

(b) radiographic lot number

(c) date of radiography

(d) penetrameter size

(e) view number.

4.4.7 Penetrameter

Two penetrameters shall be included in each radiographic view near the outer edge of the cone of radiation as shown in Fig. 1. The penetrameters shall consist of a single strand of AWG size 48 copper wire (0.00124 inch diameter) placed over the body of an item identical to those being radiographed. The wire shall be located on the surface of the item farthest from the film. The wire may be taped to the item with any tape that does not impair the radiographic image of the penetrameter and item. The item over which the penetrameter is placed shall be removed from the radiographic lot. Penetrameter image shall be clearly visible when viewed optically at 20X magnification.

4.4.8 Radiation Source

The radiation source shall be an X-ray machine having a voltage range of 50 to 150 kv (effective) and a focal spot of 2.5 mm or less.

4.4.9 Radiographic Techniques

The radiographic techniques shall be adjusted to achieve maximum sensitivity and shall be such as to produce a clearly defined image of the penetrameter. The film used shall be a very fine grain, "Eastman M" single emulsion, or Gaevert "D-2" single emulsion or equivalent. Average film density of the item body enclosure area shall be in the range of 1.8 to 2.5. The techniques used shall be the same for both views of a radiographic lot.

4.4.10 Film Examination

The image of each item shall be examined using optical equipment capable of magnifying the image at least 20 diameters. The optical equipment shall also be capable of measuring in thousandths of an inch. Radiographic images of rejected items shall be so marked on the film.

4.4.11 Radiographic Report

Three copies of the radiographic report and all required radiographs shall be furnished with each radiographic lot delivered to the contractor. The radiographic report shall contain the following information:

(a) radiographic lot number

(b) date of radiography

(c) item manufacturer

(d) item type by contractor's part number

(e) contractor's purchase order number

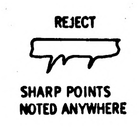
(f) radiographic laboratory

(g) penetrameter type and size.

4.5 Inspection

(1) Inspect the bellows for excessive internal solder build-up by means of an X-ray photograph. Fig. 2 indicates X-ray cross-section views of bellows which are acceptable and unacceptable with regard to solder build-up. Fill holes shall be limited to two per bellows.

(2) Check for solder, residue, or foreign matter on the inside after sealing. The criterion for rejection shall be as follows:



A maximum of five particles are acceptable inside the bellows. The largest particle shall not exceed 0.007 inch in any dimension. The number of particles whose largest dimension is greater than 0.003 inch shall not exceed three.

5. TEST PROCEDURES

The various tests referred to in this specification shall be performed as follows:

5.1 Visual Inspection

Each bellows shall be examined critically under 10X to 20X magnification to determine that the elements of workmanship are as specified in para. 3.3.1.

5.2 Volume Compensation Test

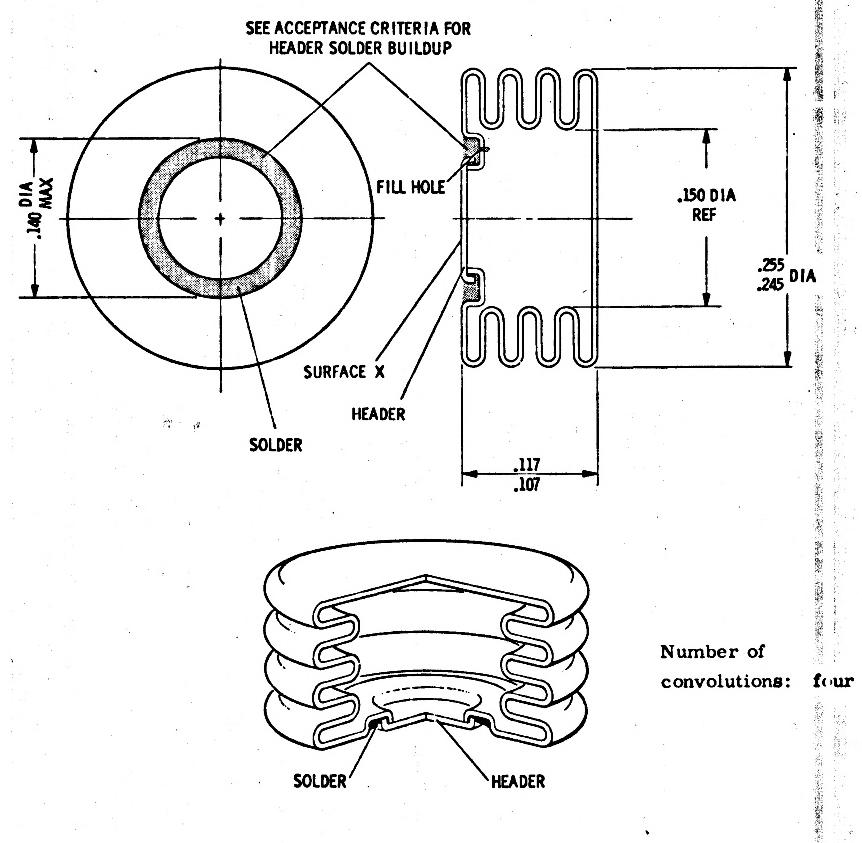
The height of each bellows as measured during exposure to 150°F at 45 ± 1 psia and then against a stop set at 0.135/0.140 inch by exposure to 72°F at 0.4 psia maximum shall meet the maximum and minimum dimensions shown on dwg. 2001688.

5.3 Environmental Test

(a) Pressure Cycling Test

Each bellows shall be pressure cycled 30 times from 0.4 psia maximum to 45 ± 5 psia at 72° ± 5°F. The cycle rate shall not exceed 60 cycles per minute.

SOLDER MUST NOT EXTEND BEYOND 0.140 DIA.
MAX. OR PROTRUDE ABOVE SURFACE X.



Number of
convolutions: four

Fig. 2 X-Ray Inspection.

(b) High Pressure Test

Each bellows shall be exposed to a pressure of 45 ± 5 psia at a temperature of 110° ± 5°F for a minimum period of two hours. Release pressure to atmospheric and measure bellows height. Units failing to fall within 0.107 and 0.117 inch shall be rejected.

(c) Vacuum Test

Each bellows shall be exposed to a pressure of 0.4 psia maximum and a temperature of 72° ± 5°F for a minimum period of two hours. A stop shall be used to limit the total length to 0.135/0.140 inch. The bellows must reach the stop and return to an overall length of 0.107 to 0.117 inch immediately when the vacuum pressure is released to atmospheric. Bellows not meeting these requirements shall be rejected.

5.4 Leak Test

Each unit shall be tested on a mass spectrometer type leak detector with a sensitivity threshold not less than 10^{-9} std cc/sec helium. Bellows shall be cleaned and vacuum-baked for 30 minutes before measurements are made. Bellows indicating a leak rate in excess of 10^{-9} std cc/sec shall be rejected.

6. PREPARATION FOR DELIVERY

6.1 General

All units shall be properly packed and prepared for delivery in such a manner that the bellows shall not be damaged while in transit to the purchaser by any normal means of transport or during storage.

APOLLO II IRIG Specification
MC 811
Release Date Nov. 4 1964
Release Revision E
Class A Release
TDRR 14046

WHEEL DYNAMOMETER RUNNING DATA

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	NASA
10/5/67	C	35601	1	R Booth	

This MC specification consists of page 1
to ___ and 1 to 1 inclusive.

TP#11938

TDRR 14046 NOV 4 1964

J.PSYHOGEOS M.C.# 811 WHEEL DYNAMOMETER RUNNING DATA

WHEEL DESIGNATION	WHEEL NO.	FINAL WHEEL WT. gms.
BRG. MFG	TYPE OF BRG.	TYPE OF RETAINER

MIN. CURRENT TO START __________ MA/Ph

MIN. POWER TO START ________ WATTS/Ph

AXIAL COMPLIANCE MECHANICAL

COMPL. ________ μ in/lb

A_D = ________________ SECONDS

σ_D = ________________ SECONDS

DATE	START	STOP	TOTAL ELAPSED TIME HOURS	MINIMUM VOLTAGE TO START VOLTS/Ph	MINIMUM VOLTAGE TO SYNC. VOLTS/Ph	POWER AT SYNC. & 28 VOLTS, WATTS/Ph	CURRENT AT SYNC. @ 28 VOLTS IN. MA	RUNUP TIME AT 28 VOLTS IN SECONDS	RUNDOWN TIME IN SECONDS 24000 TO 6000 / 6000 TO ZERO	SLOW RUNNING TORQUE IN Dy/cm	RUNNING TORQUE IN Dy/cm	TEMP °F	

TP5972 (REV B 12/4/62)
(REV C 10/5/67)

APOLLO II IRIG Specification
MC #900F
Release Date Nov. 18, 1964
Release Revision E
Class A Release
TDRR 14363

Date	Revision Letter	TDRR No.	Pages Revised	Approval	
				MIT	NASA
6/24/68	F	36390	1	PRK	

TP#11938

This MC specification consists of page 1
to____and 1 to____inclusive.

INSTRUMENTATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

TDRR 36390 JUN 24 1968

PREPARED BY: James M. Aitken
DATE: August 6, 1957 M.C. #900F
SHEET 1 OF 1

Cleaning Microsyn and Suspension Laminations

D Oakite Cleaner 61 B- Oakite Corporation or
Alconox - Alconox Corporation

Distilled Water C.P. Acetone

1. Measure lamination stacks and arrange on cleaning racks, so that flat surfaces of each lamination are exposed to cleaning solutions.

2. Separate each measured stack by spacers.

D 3. MIXTURE RATIO: Oakite Cleaner 61 B/Distilled Water = 4 to 8 oz/gal. [illegible]. Boil to make solution. (See Note 1).

4. Heat cleaning bath to 180°F ± 3°. Hold constant.

5. Immerse racked laminations in bath for 1/2 hour.

6. Agitate solution throughout process and keep within temperature range.

7. Remove racked laminations from cleaning solution.

8. Submerge immediately in pan of water, so that no part of any lamination will be allowed to air-dry.

E 9. Rinse under running tap water for 1/2 hour. (See Note 2). Alternate rinse: Rinse under running tap water for 15 minutes followed by a 2 minute deionized water rinse.

10. Transfer laminations from rinse water directly into C.P. Acetone testing frequently for "water break". (See Note 3).

11. After Acetone dip, laminations are air-dried on clean paper towels

E 12. Store in clean, dry, closed containers. Alternate storage: Laminations may be stored by immersing in anhydrous alcohol.

NOTES: 1. Bath may be used over and over again with no additions other than distilled water to make up evaporation losses. Do NOT add more Oakite, or tap water. When bath fails [illegible] to give good "water break" on laminations, drain, clean tank and fill with fresh filtered solution.

E 2. Never handle laminations with fingers after removing from bath. Forceps, cleaned in Oakite Cleaner 61 A, should be used throughout remainder of process.

3. If "water break" is imperfect on any one lamination, entire cleaning process must be repeated for all laminations. Pieces re-checked for "water break" should always be dipped in Acetone before drying and coating with Cycleweld.

Rev. E 9/1/64
Rev. D 5/22/64
Rev. C 5/21/62
Rev. May 1959
Rev. B 10/22/59

APOLLO II IRIG Specification
MC 904C
Release Date ______
Release Revision B
Class 1 Release
TDRR 14046

Title: Cleaning Procedure for 25 Mod 1 and 25 Apollo II

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
3/28/68	C	36404	Revised & Rewritten	PRK	

TP#11938

This MC specification consists of page 1 to ___ and 1 to 2 inclusive.

Cleaning Procedure For 25 Mod 1 and 25 Apollo II

1.0 Solvents

1.1 Trichloroethylene (Reagent)
1.2 Varsol (grade #2)
1.3 Acetone (Reagent)
1.4 Filtered Freon (PCA)

2.0 Trichloroethylene

2.1 All piece parts as received or after lapping and polishing operations are ultrasonically cleaned in clean trichloroethylene for three (3) to five (5) minutes. Follow by an ultrasonic rinse in clean freon for a minimum of three (3) minutes.

Note: Above step does not apply to potted or cemented pieces that may be affected by trichloroethylene.

2.2 Solder joints are brushed with an acid or artist brush using clean trichloroethylene, followed by a brushing with clean freon. Alternate: Clean solder joints using Kester AP-20

2.3 After tinning of all the shroud parts and after assembly of the seals, scrub all the parts with trichloroethylene and an acid brush. Follow by scrubbing under running hot water using Ajax, powdered boraxo or equivalent. Rinse under running hot water and thoroughly dry.

2.4 Clean bellows area of residual BFC fluid after unit cap off with an eye dropper and trichloroethylene, followed by a freon rinsing.

2.5 Fill fixture hardware prior to use to be cleaned by rinsing in clean filtered freon. After unit fill, clean fixture parts by soaking in trichloroethylene, followed by cleaning in freon vapor degreaser.

3.0 Varsol (Grade #2)

3.1 For all components that have been exposed to BFC fill fluid. Refer to MC 25-902.

3.2 After tank work carefully, clean the float by scrubbing with an acid brush while immersed in clean warm varsol 90°F ± 5°. Follow by a thorough rinsing in clean warm freon 90°F ± 5°. Repeat cleaning two-three times changing the fluid each time.

3.3 After grinding operation clean the motor stator by scrubbing while immersed in clean varsol, follow by a rinsing in clean freon.

3.4 After final grind and prior to the 150 hours pump down, clean the potted end housing assemblies as indicated in step 3.2.

4.0 Acetone

4.1 Remove the bluing with a Kimwipe dampened in Acetone. Follow by cleaning as in step 3.2.

5.0 Filtered Freon

5.1 Float hardware is thoroughly rinsed in clean filtered freon prior to wheel installation. Follow with thorough vacuuming.

5.2 All unit parts, tools and fixtures are cleaned as in step 5.1 prior to and during final assembly.

5.3 Clean filtered freon is used for flushing operation.

APOLLO II IRIG Specification
MC 25-854
Release Date 18 Nov. 1964
Release Revision A
Class A Release
TDRR 14363

Apollo II IRIG
Dry Centering Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/13/65	B	18306	1	WK	WJR

TP#11938

This MC specification consists of page i to____and 1 to 5 inclusive.

Rev B 4-13-65
Rev. A 11-9-64 Revised and Rewritten

APOLLO II IRIG DRY CENTERING PROCEDURE

1. Preliminary

1.1 Mount unit in Fixture D-87262 with + SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Figure #1 and check continuity through cabling.

1.3 Heat unit to 135° ± 5°F and maintain temperature.

1.4 Excite gyro per Figure #1 at 10.0 volts ± 1%.

1.5 Center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position.

2. Angular Alignment of Microsyns

2.1 Rotate the gyro about OA from + SRA down to + SRA up and back to down. Observe radial signal relative phases. A phase reversal indicates radial freedom, which must be attained before continuing.

2.2 Drive the float electrically between angular stops by torquing per Figure #1 insert, and ensure that the + IA and + SRA balance paddles are rotationally centered in the 12-72 balance weights. Nominal torquing current required is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 87262.2 until the angular stop voltages are equal within 10 millivolts.

B 2.4 With the T. G. excited as a signal generator as in Figure #1, note the magnitude and phase of V_o. Rotate the T. G. end housing until V_o has the same relative phase as in MC 25-860 Step 3.5, and is [illegible] at the null voltage within 2 mv, or V_o within ± 2 mv of MC 25-860, Step 3.5 if the latter value is higher than null.

TDRR 14363 NOV 18 1964

2.5 Using an adjustable C- clamp as a tool, clamp the end housing tight to the main housing. The parts should bottom to give line-on-line fit when examined with an eye loupe.

2.6 Repeat Step 2.1 and note phase and magnitude of radial signals. The maximum acceptable centering ratio is 6:1.

3. Setting End Shake

3.1 With the unit in the OA vertical up position, adjust the T. G. pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 20±1 ma. Adjust the S. G. pivot, if necessary, to ensure that the float does not become locked between the pivots.

3.2 Use the axial sensitivity of 0.27 ma/0.0001 in. and retract the T. G. pivot 0.00075 inch (1/2 the total end shake) by monitoring the change in the T. G. suspension current.

3.3 Advance the S. G. pivot until it just bottoms.

3.4 Slowly rotate the gyro until the OA is vertical down.

3.5 Retract the S. G. pivot until the suspension currents are equal and then using the same calibration, retract the S. G. pivot .00075 inches by monitoring the change in the S. G. suspension current.

ALLOWABLE END SHAKE .0015 ± .0005

3.6 With the gyro in the OA vertical position, apply a very small amount of LCA-9 adhesive (MC 25-302) to the pivot and end housing at three points 120° apart. Cure per MC 25-302. Rotate to the S. G. up position and repeat the cementing procedure.

3.7 Remove the pivot adjustment fixtures.

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---

4. Cementing Clamping Caps

4.1 Recheck angular stops and microsyn alignments, re-adjusting as necessary.

4.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

4.3 Coat the threads on the clamping cap with Epon 828 and assemble to the unit. Wipe off excess cement.

4.4 Check the angular centering and make any necessary adjustments before cement sets up. Keep the unit OA vertical for one-half hour with the cemented end up.

4.5 Repeat 4.2 and 4.3 for other end and cure at 137°F for one hour.

5. Final Alignment Checks

5.1 Repeat 2.1 recording magnitude and phase of the radial signals. Maximum acceptable centering ratio is 6:1.

5.2 Recheck microsyn alignments and end shake. Record end shake currents and S. G. stop voltages.

5.3 Refer to MC 25-853 for continuation of final assembly.

TDRR 14363 NOV 18 1964

DATA SHEET

2.4 Information from MC 25-860, 3.5

E_o = __________ mv O phase

Measurements from 2.5

E_o = __________ mv O phase

5.1 SGX __________ TGX __________

SRA up

SGY __________ TGY __________

SGX __________ TGX __________

SRA down

SGY __________ TGY __________

Centering Radios

SX __________ TX __________

SY __________ TY __________

5.2 Final suspension currents

OA up

I_{ms} __________ ma

I_{mt} __________ ma

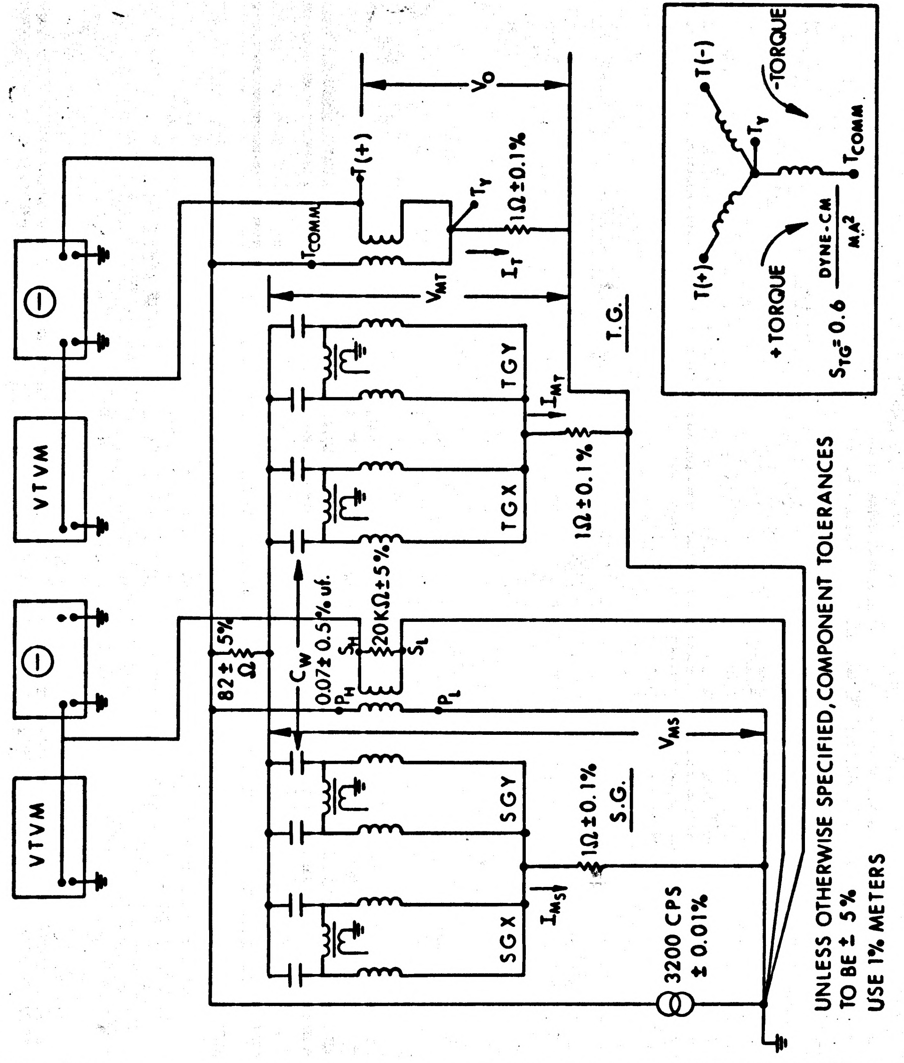
OA down

I_{ms} __________ ma

I_{mt} __________ ma

Cw Stop __________ mv

CCw Stop __________ mv


T(+)
T(-)
T_Y
T_{COMM}
+TORQUE
-TORQUE
S_{TG} = 0.6 DYNE-CM / MA²
V_o
T_{COMM}
T_Y
1Ω±0.1%
I_T
V_{MT}
T.G.
TGY
TGX
I_{MT}
1Ω±0.1%
VTVM
VTVM
C_W
0.07±0.5% uf.
20KΩ±5%
82±5% Ω
S_H
S_L
P_H
P_L
V_{MS}
SGY
SGX
1Ω±0.1%
S.G.
I_{MS}
3200 CPS ± 0.01%

UNLESS OTHERWISE SPECIFIED, COMPONENT TOLERANCES TO BE ± 5%
USE 1% METERS

Figure #1

APOLLO II IRIG Specification
MC 25-854
Release Date 18 Nov. 1964
Release Revision A
Class A Release
TDRR 14363

Apollo II IRIG
Dry Centering Procedure

Date	Revision Letter	TDRR No.	Pages Revised	Approval MIT	Approval NASA
4/13/65	B	18306	1	WK.	WJR
1/25/65	C	27051	2	WK.	Jm

This MC specification consists of page i to ___ and 1 to 5 inclusive.

TP#11938

TDRR 14363 NOV 18 1964

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964
MC 25-854
SHEET 1 of 5

Rev B 4-13-65
Rev. A 11-9-64 Revised and Rewritten

APOLLO II IRIG DRY CENTERING PROCEDURE

1. Preliminary

1.1 Mount unit in Fixture D-87262 with +SRA vertically down and check electrical continuity of the unit.

1.2 Connect unit to console per Figure #1 and check continuity through cabling.

1.3 Heat unit to 135° ± 5°F and maintain temperature.

1.4 Excite gyro per Figure #1 at 10.0 volts ± 1%.

1.5 Center the float along the output axis (OA) to achieve suspension currents equal within 1 ma. Back off each pivot one-half turn from this axially centered position.

2. Angular Alignment of Microsyns

2.1 Rotate the gyro about OA from +SRA down to +SRA up and back to down. Observe radial signal relative phases. A phase reversal indicates radial freedom, which must be attained before continuing.

2.2 Drive the float electrically between angular stops by torquing per Figure #1 insert, and ensure that the +IA and +SRA balance paddles are rotationally centered in the 12-72 balance weights. Nominal torquing current required is 50 ma.

2.3 Rotate the signal generator end housing manually with tool 87262.2 until the angular stop voltages are equal within 10 millivolts.

B 2.4 With the T. G. excited as a signal generator as in Figure #1, note the magnitude and phase of V_o. Rotate the T. G. end housing until V_o has the same relative phase as in MC 25-860 Step 3.5, and is ~~is at the null voltage~~ within 2 mv, or Vo within ± 2 mv of MC 25-860, Step 3.5 if the latter value is higher than null.

TDRR 14363 NOV 18 1964

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964
MC 25-854
SHEET 2 of 5

2.5 Using an adjustable C- clamp as a tool, clamp the end housing tight to the main housing. The parts should bottom to give line-on-line fit when examined with an eye loupe.

2.6 Repeat Step 2.1 and note phase and magnitude of radial signals. The maximum acceptable centering ratio is 6:1.

3. Setting End Shake

3.1 With the unit in the OA vertical up position, adjust the T. G. pivot and the excitation voltage until the suspension currents are equal within 0.5 ma at 20±1 ma. Adjust the S. G. pivot, if necessary, to ensure that the float does not become locked between the pivots.

C 3.2 Use the axial sensitivity of 0.27 ma/0.0001 in. and retract the T. G. pivot 0.00060 inch (1/2 the total end shake) by monitoring the change in the T. G. suspension current.

3.3 Advance the S. G. pivot until it just bottoms.

3.4 Slowly rotate the gyro until the OA is vertical down.

C 3.5 Retract the S. G. pivot until the suspension currents are equal and then using the same calibration, retract the S. G. pivot .00060 inches by monitoring the change in the S. G. suspension current.

ALLOWABLE END SHAKE 0.0009±0.0015

3.6 With the gyro in the OA vertical position, apply a very small amount of LCA-9 adhesive (MC 25-302) to the pivot and end housing at three points 120° apart. Cure per MC 25-302. Rotate to the S. G. up position and repeat the cementing procedure.

3.7 Remove the pivot adjustment fixtures.

TDRR 14363 NOV 18 1964

PREPARED BY: J. Aronson
H. Vernon
DATE: February 27, 1964
MC 25-854
SHEET 3 of 5

4. Cementing Clamping Caps

4.1 Recheck angular stops and microsyn alignments, re-adjusting as necessary.

4.2 Apply a generous amount of Epon 828 adhesive to the main housing threads on one end.

4.3 Coat the threads on the clamping cap with Epon 828 and assemble to the unit. Wipe off excess cement.

4.4 Check the angular centering and make any necessary adjustments before cement sets up. Keep the unit OA vertical for one-half hour with the cemented end up.

4.5 Repeat 4.2 and 4.3 for other end and cure at 137°F for one hour.

5. Final Alignment Checks

5.1 Repeat 2.1 recording magnitude and phase of the radial signals. Maximum acceptable centering ratio is 6:1.

5.2 Recheck microsyn alignments and end shake. Record end shake currents and S. G. stop voltages.

5.3 Refer to MC 25-853 for continuation of final assembly.

TDRR 14363 NOV 18 1964

DATA SHEET

2.4 Information from MC 25-860, 3.5

E_o = __________ mv O phase

Measurements from 2.5

E_o = __________ mv O phase

5.1

SRA up	SGX	__________	TGX	__________
	SGY	__________	TGY	__________
	SGX	__________	TGX	__________
SRA down	SGY	__________	TGY	__________

Centering Radios

SX	__________	TX	__________
SY	__________	TY	__________

5.2 Final suspension currents

OA up

I_{ms} __________ ma

I_{mt} __________ ma

OA down

I_{ms} __________ ma

I_{mt} __________ ma

Cw Stop __________ mv

CCw Stop __________ mv

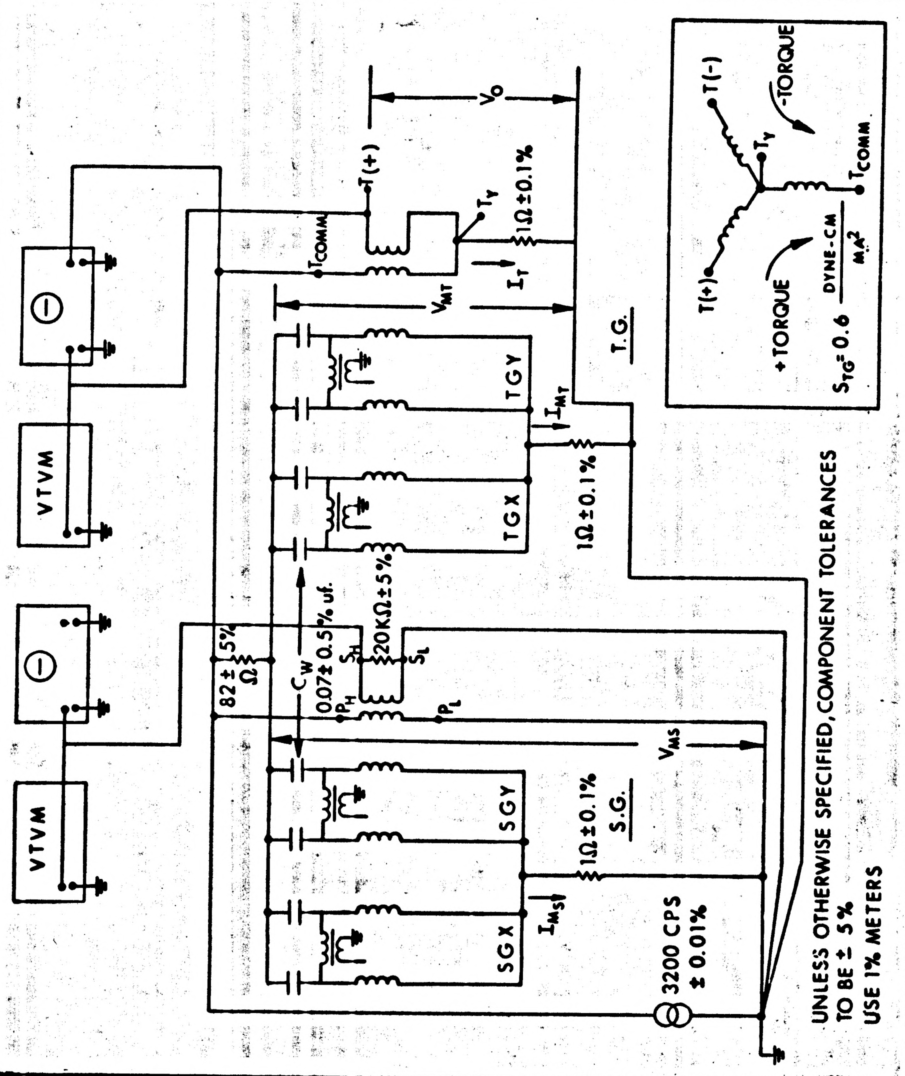

VTVM
VTVM
V_o
T(+)
T_{COMM}
T_Y
$1\Omega \pm 0.1\%$
I_T
V_{MT}
TGY
TGX
I_{MT}
$1\Omega \pm 0.1\%$
T.G.
C_W
$0.07 \pm 0.5\%$ uf.
$82 \pm 5\%$ Ω
$20K\Omega \pm 5\%$
S_H
S_L
P_H
P_L
V_{MS}
SGY
SGX
I_{MS}
$1\Omega \pm 0.1\%$
S.G.
3200 CPS
± 0.01%
T(+)
T(-)
T_Y
T_{COMM}
+TORQUE
-TORQUE
$S_{TG} = 0.6 \frac{DYNE\text{-}CM}{MA^2}$
UNLESS OTHERWISE SPECIFIED, COMPONENT TOLERANCES
TO BE ± 5%
USE 1% METERS

Figure #1